

**SHAHEED BENAZIR BHUTTO UNIVERSITY**  
**SHERINGAL DIR UPPER KHYBER PAKHTUNKHWA**  
**PAKISTAN.**

- **PC-1 ITEM:- CONSTRUCTION OF MICRO HYDEL POWER**
- **PROJECT NAME:- DEVELOPMENT OF UNIVERSITY OF DIR SHERINGAL.**
- **SPONSORING AGENCY: HIGHER EDUCATION COMMISSION, ISLAMABAD.**
- **FUNDING AGENCY: PLANNING COMMISSION, GOP.**

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**EPC/Turnkey BIDDING DOCUMENTS**

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**VOLUME-II**

**Part III. Employer's Requirement**

**FEBRUARY 2023**



**ACE (PVT) LTD.**

**ASSOCIATED CONSULTING ENGINEERS - ACE (PVT)  
LTD. ARCHITECTURAL AND TOWN PLANNING SERVICES  
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**EPC/ TURNKEY BIDDING DOCUMENT**  
for  
**Design, Procurement and Construction**  
of  
**Micro Hydel Power Project**

**Volume – 2**

**Part III. Employer's Requirement**

Contract No.: SBBU-MHP-02

**FEBRUARY 2023**



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## Table of Contents - Summary Description

### Volume 1: Bidding Documents

#### **PART I BIDDING PROCEDURES**

1 -	Invitation for Bids-----	I-3
2 -	Instructions to Bidders and Appendices -----	I-8
3 -	Letter of Technical Bid & Schedules to Bid -----	I-49
4 -	Letter of Price Bid & Schedules to Bid -----	I-68
5 -	Schedule of Prices -----	I-75

#### **PART II CONDITIONS OF CONTRACT AND STANDARD FORMS**

1-	Preamble to Conditions of Contract-----	I-2
2 -	General Conditions of Contract (GCC) -----	II-13
3 -	Particular Conditions of Contract (PCC) -----	II-64
4 -	Standard Forms (SF) -----	II-98

#### **PART III EMPLOYER'S REQUIREMENTS**

1-	Scope of Work -----	I-2
2 -	Drawings-----	I-77

#### **Volume 2 Supplementary information**

**(if any, please attach here)**



## 1. Employers Requirements

### 1.1 Scope of Work

#### 1.1.1 General

Micro Hydrel Power station at Shaheed Benazir Bhutto University (SBBU) Sheringal-Upper Dir with an estimated capacity of 250 KW will be constructed as a run of river type hydropower plant on Punjkora River.

Already completed works:

- Partially headrace Channel, Forebay, have been completed.

The works comprise:

- Civil works and electro-mechanical works of Intake structure at Forebay.
- Detailed design of Penstock along with water hammer analysis.
- Laying and installation of Penstock along with civil works.
- Powerhouse building & infrastructural works and ancillary structures.
- Intake, remaining works of channel, Forebay, Tailrace channel and ancillary structures.
- Raising of existing channel or covering with RCC if bidder's design require the same.
- Hydraulic steel works i.e. gates, stoplogs, trashracks, water-tight door etc.
- Two (2) horizontal shaft cross flow turbines each with rated output of 143.5 KW each including inlet valves, governor system and all auxiliary equipment.
- Two (2) horizontal shaft generators of 162 KVA each including excitation system, automatic voltage regulators, along with all control panels, switch gears, cables, alarm system, generator protection etc.
- Power house auxiliary systems i.e. cooling water system, service & potable water system, waste and sewerage system, dewatering and drainage system, compressed air system, oil handling system and HVAC system.
- Radio operated Powerhouse crane (5/1 tonne) and 1 tonne JIB crane for handling of DT stoplogs.
- Workshop equipment and tools.
- Access roads to Power House (1Km approx.) including causeways, bridges, culverts and proper drainage system.
- Ancillary and environmental works necessary for the proper operation of the project.

The Contractor shall design, procure the necessary equipment and materials, construct, install, test, start-up, commission the SBBU Hydropower Project. This Section describes the Scope of Work, to be performed by the Contractor under a EPC contract to provide the Employer with the complete SBBU Hydropower Project.

The Contractor shall be responsible for all aspects of design and construction of the Project in accordance with the design criteria and specifications furnished herein, and in accordance with additional and supplementary design criteria and specifications prepared by the Contractor and accepted by the Employer.

The scope of work to be carried out by the Contractor will include, but not be limited to:

- Contractor will be responsible to arrange a strong state of the art required design team or produce an MOU with some reputed Engineering Consulting Firm.
- Preparation of all detailed design criteria, design analysis, design calculations, construction specifications, detailed construction and shop drawings, quality control procedures, and Environmental Management Plans necessary for the complete construction of the project together with Operation and Maintenance (O&M) Manuals, and as built record drawings.
- Temporary and Permanent Access Roads, Cross Drainage Structures and Infrastructural Facilities.
- Finalization of overall layout of the project.
- Physical and computational model study for confirmation of design for different hydraulic structures as well as electromechanical equipment in consultation with Employer/ Engineer (If needed).
- Layout of individual project components including equipment layout in the Power House and other ancillaries.
- Any additional Site Investigations and Laboratory Testing needed to develop the detailed designs.
- Preparation of detailed construction drawings, necessary shop drawings, Bar bending schedules etc. for Civil Works and erection sequence drawings for E & M Equipment.
- Telecommunication and e-mail facility.
- Quality Plan and QA system.
- Health and Safety Measures Plans
- Preparation of Construction Programme and Method Statements
- Construction of Civil Works
- Fabrication, delivery to site, erection, testing and commissioning of specified Plants
- Provision of Operation and Maintenance (O&M) Manuals in English language.
- Design reports and Drawings.
- Preparation of construction drawings.
- As-built record of drawings.
- Preparation of Project completion report.
- Training of Employer's O&M staff
- All temporary works required to construct the Project, including Processing and Concrete batching plants and offices, Field Cabins and living accommodation (international standards) for Contractor's staff and site laboratory buildings, steel fabrication workshop, Penstock fabrication workshop, plant maintenance workshops, storage facilities, First Aid, utilities etc.

### **1.1.2 Detailed Design and Planning of the Works**

The Contractor shall perform engineering services pertinent to planning and detailed design of the Works in accordance with accepted international standards. In addition, the Contractor shall establish a Quality Control/Quality Assurance program to verify that the Work performed by the Contractor is in accordance with the requirements of the Contract.

### 1.1.2.1 Detailed Design

All Designs shall be performed in accordance with the requirements given in the following Section, Basic Design Criteria. The Design responsibilities of the Contractor shall be as follows:

- (a) The Contractor shall carry out the Detailed Design and prepare construction drawings of the Permanent Works to be performed under this Contract and the site investigations/ laboratory testing deemed necessary for detailing the design;
- (b) The Contractor shall prepare the Detailed Design and drawings of the necessary Temporary Works to be performed under this Contract;
- (c) The Contractor shall prepare Construction Method Statements and an Execution and Implementation Plan;
- (d) The Contractor shall prepare the Detailed Design and Connection Shop Drawings of the Hydro-mechanical and Electro-mechanical equipment to be installed under this Contract;

The activities to be performed under the detailed design are outlined below:

- Additional investigations and laboratory testing;
- Additional topographic survey;
- Setting out survey of the Project area limits at the Project Site;
- Expansion and clarification of design criteria and parameters;
- Review the work done and prepare summary of all tests and investigations planned to be carried out in connection with the Detailed Design;
- Design Memoranda;
- Detailed Design calculations;
- Civil Works Construction and Shop Drawings;
- Providing and/or incorporating Manufacturer's Drawings;
- Report on construction methods to be used for all major works;
- Manufacturing and delivery Schedule for major equipment;
- Layout drawings for all temporary works including test laboratories;
- Principal items of Processing, Production & Construction plants to be used;
- Detailed information of site offices and camp facilities;
- Quality Control and Quality Assurance plans and procedures for Construction;
- Plan for borrow areas and for disposal of spoil material;
- Environmental Management Plan including measures for rehabilitation of work areas;
- Construction Security, Health and Safety plans; and
- Basic outline of the Operation and Maintenance Manuals, and proposed Training Program

For each structural feature of the project, the Contractor shall prepare Detailed Design documentation to include as a minimum for the review of Employer:

- Description of each structure;
- Review of assumptions and design procedures adopted, design criteria, loads, load cases used and the safety factors;
- Short description of each method of analysis, computer programs, software, etc. used;
- Calculations and principal results of the detailed design analyses;
- Detailed design drawings and specifications for construction;
- Manufacturer's shop drawings.
- All other information necessary for construction/ completion of works;

#### **1.1.2.2 Temporary Site Installations**

The Contractor shall design, install and maintain throughout the execution of the Works all temporary facilities, such as, but not limited to, Survey control points, foundations for construction plant, workshops, offices, site laboratory (to carry out all necessary tests) and stores etc. required for the Work.

On completion of the Project, the Contractor shall remove all temporary facilities, including their foundations that are not handed over to the Employer, and restore the area to a level acceptable to the Employer.

#### **1.1.2.3 Temporary Facilities to be handed over to the Employer**

At the Completion date, selected temporary facilities or part there of shall be handed over to the Employer if and as the Employer requires. These facilities shall be handed over to the Employer at no additional cost in good and serviceable conditions so that these can be utilized by the Employer without any further treatment or renovation.

#### **1.1.2.4 Construction Power and Water Supply**

The Contractor shall be responsible for the design and provision of temporary power supply for all sites during construction of the works.

The Contractor shall be responsible for the supply of potable water as well as treatment/ disposal of waste water as well as appropriate disposal of solid waste acceptable to the Employer.

#### **1.1.2.5 Site Offices and Other Facilities**

The Contractor shall provide the site offices and other facilities for its own use.



# **EMPLOYER'S REQUIREMENTS**

## **CHAPTER-1**

### **GENERAL REQUIREMENTS FOR MECHANICAL WORKS**

250 KW SBBU Micro Hydropower Project

## General

This chapter covers, in general, the Employer's requirements for Technical Specifications of Mechanical Works of SBBU Micro Hydropower Project. If the provisions of this section conflict with the requirements of the other (equipment specific) sections then the requirements of the other (equipment specific) sections shall prevail.

### General Design Requirements

As far as possible the equipment shall be of the Contractor's standard design, provided that this design is in accordance with the requirements of these Technical Specifications being specified hereinafter. All equipment and components of the plant shall have proven and satisfactory services and the EPC Contractor shall be responsible to provide the evidence of successful commissioning of similar projects to demonstrate his experience in the field.

All equipment performing similar duties shall be of the same type and quality and mutually interchangeable.

### Applicability of Standards

The Works shall conform to the following general groups of Standards. The Contractor shall refer to Standards within these general groups in defining the characteristics of the Plant in his scope of supply. These groups of Standards shall be referenced in the contractual information presented for approval by the Contractor.

The Contractor shall be responsible for providing latest copies of all referred codes and standard (both in hard and soft form as agreed by the Employer/Engineer) with or before submission of the plant design for approval of the Employer/Engineer.

**Table 1-1 Standard Used**

No.	Description	Code
1	Dimensions and units	ISO
2	Ferrous and non-ferrous material for fabrication	ASTM
3	Pressure Vessel design and manufacture	ASME
4	Welding procedures and welder qualifications for pressure vessels	ASME
5	Structural welding	AWS
6	Non-destructive testing	ASME & ASTM
7	Materials testing	ASTM
8	Pipework, supports	ANSI
9	Pipe, pipe flanges and valves	ISO
10	Noise and Vibration	ISO

No.	Description	Code
11	Fastenings	ISO
12	Pumps and fans	ISO
13	Painting	SSPC
14	Electrical equipment	IEC
15	Hoisting and handling equipment	FEM

**Table-1.2: Standard Codes Full Names**

Code Abbreviation	Code Full Name
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
FEM	<i>Federation Europeene De La Manutention</i>
IEC	International Electrotechnical Commission
BS	British Standard
ANSI	American National Standards Institute
ISO	International Standards Organization
SSPC	The Society for Protective Coatings

**i. General Compliance with International Standards and Codes**

All works under this Contract shall comply with the relevant latest Standards of the country in which the Plant is to be installed, provided that there is no conflict with the Standards of the country of installation and the relevant International Standards and Design Codes. Where suitable International Standards do not exist, internationally accepted Standards shall apply.

**ii. Standards Named in Specification**

Although the Works shall generally comply with International Standards, any instruction in this Specification that a particular aspect of the Works shall comply with a named Code or Standard shall take precedence, and that particular aspect of the Works shall comply with the named Code or Standard.

**Program to be provided**

Detailed program of performance of the Contract shall be submitted in the form of the Critical Path Method (CPM), or Critical Path Analysis (CPA) and PERT network or other accepted programs spanning the period from the Effective Date to the Completion Date of the Project.

The detailed program shall also be established in the form of bar charts.

The detailed program of performance of the Project shall also include the following:

- i. Time lines for Employment of various categories.
- ii. Local material procurement process.
- iii. Impact of Material / goods imports (if any).

### **Drawings and Information**

All drawings shall be prepared to relevant ISO Standard using latest versions of software such as AutoCAD and shall be submitted both in electronically and in hard (A3/A2 size printed) format.

All drawings shall be prepared to the scale, fully detailed and with the size of A3/A2, in the English Language and SI units.

These drawings together with copies of the drawings originally issued with the bid documents shall then be bound up either in the Contract Document or in a separate folder and shall be signed both by the Employer/Engineer and the Contractor for purposes of identification.

#### **iii. Indexing and Drawing Identification**

All Drawings, Schematics, System Principal Diagrams, Layout Plans, Equipment General Arrangements, Details of Terminal points, Foundation details, Design Descriptions and Design Calculations shall be assigned a unique identification number as per agreed nomenclature between EPC Contractor and Employer/Engineer.

Prior to submitting these items for Employer/Engineer's review, the Contractor shall submit a schedule of index of all his documents with serial number, document/drawing titles, unique document/drawing number and tentative date of submission.

Employer/ Engineer may require any additional drawings/documents for information any time after the bid or even during Project execution. Plant and system diagrams shall each be accompanied by a design philosophy which shall describe the basis for sizing and describe the principal features of all major components within the system, as well as system operation, control and protection.

#### **iv. Design Submissions by EPC Contractor**

Before commencement of any portion of the works the EPC Contractor shall submit the detailed design of all EM Equipment for Employer/Engineer's approval. This design shall include the following submittals:

- i. Systems Principal Diagrams (Schematics) of all auxiliary systems.
- ii. Single line diagram (Electrical)
- iii. Design calculations for Hydraulic steel structures including Penstocks, Gates, Air vent valves, Trash racks, Gate lifting mechanisms, embedded parts, supports and anchorages etc.

- iv. Design calculations for turbine, MIV (butterfly Valve), Hydraulic and Electrical parts of the digital governors etc.
- v. All relevant drawings showing maximum EM equipment detail, dimensions, component identifications and other data relating to the equipment and materials to be used or as advised by the Employer/Engineer to determine the acceptability of the proposed design.
- vi. Shop drawings of the Powerhouse with complete information of the layout and the system with respect to EM equipment as well as Civil structures.

**v. Sequence of Drawings**

Following sequence for submission of drawings shall be observed:

**a. Project/Powerhouse Layout Drawings based on Tender drawings**

EPC Contractor shall submit Project / Powerhouse layout drawings based on Tender Drawings within 14 days of the Contract Award. In this submission the Contractor shall verify all the available spaces, clearances and coordinates of different project entities after a comprehensive combined visit of the site by Employer/Engineer and Contractors and analysis of the topographic surveys conducted independently by the Contractors.

Employer/Engineer shall review this set of drawings and convey his comments (if any) within 14 days of the submission. The contractor shall be responsible to revise the drawings up to the satisfaction of the Employer/Engineer's Engineer and resubmit for review. The process shall be repeated till approval is accorded.

**b. Equipment General Arrangement Drawings**

After approval of the Project/Powerhouse Layout drawings, the Contractor shall submit equipment general arrangement drawings having all details of relevant embedded parts, buried sleeves and concrete openings / recesses, foundation details, equipment layout arrangements, equipment weights and all necessary dimensions required for cordially placement of the Plant.

These drawings shall also carry sufficient detail of equipment handling during installation and provide the following:

- i. Detail of overhead embedded hooks for lifting of Equipment on each floor
- ii. Interfacing detail of EM and Civil components during installation.

**c. Excavation and Concrete Lift Drawings**

Excavation and Concrete lift drawings shall be submitted by the Contractor on the basis of approved equipment arrangement drawings as stated above. Packages of these drawings shall be submitted progressively as the project moves forward as per approved Project Schedule / Program mentioned above.

All Concrete lift drawings shall have detail of embedded parts, sleeves, recesses provided by EPC Contractor through general arrangement drawings.

**d. Coordinated Shop drawings**

A Coordinated shop drawing is the one which has all the piping, cabling, cable trays, ducting, equipment layout and concrete lifting detail presented in different layers. These drawings help to find out any conflict, clashes and interfacing among different auxiliary systems and components of the plant.

All Coordinated shop drawings shall have references of relevant Project/Powerhouse Layout Drawings, Tender drawings (a), Equipment General Arrangement Drawings (b) and Excavation and Concrete Lift Drawings (c).

The Approved set of shop drawings shall be considered the final set of drawings to be used by the site supervision team of the Employer/Engineer during execution of the project, however the EPC Contractor shall be responsible to follow all the approved drawings in the best interest of the Project, highlight any clashes or interfacing issues between different Plant Components and propose the best engineering solution to resolve these issues without claiming any EOT or additional costs.

**e. Concrete reinforcement drawings**

This set of drawings shall have sufficient structural details and shall be covered under Civil structural details covered elsewhere in the civil part of the documents.

**Tests and Inspection**

Whenever the Plant and Equipment is manufactured and is ready for testing and / or inspection, the Contractor shall give at least 14 days advance notice to the Employer/Engineer intimating the date and place of testing and / or inspection of the equipment. On receipt of the notice the Employer/ Engineer shall give the contractor within Fourteen (14) days' notice of his intention whether or not to attend the testing and / or inspection. The Contractor shall obtain from the relevant manufacturer, vendor or sub-contractor any necessary permission or consent to enable the Employer/Engineer's (or their designated representatives) to witness the testing and / or inspection. The Contractor shall provide all assistance including labour, materials, electricity, fuel, stores, apparatus and instruments required to carry out the tests and inspections efficiently.

Before proceeding for a test or inspection either at Manufacturer's facilities, third party workshop as agreed or at site the Contractor shall submit a detailed inspection and testing plan for approval of the Employer/ Engineer.

The total cost of performing any test shall be borne by the Contractor if such tests are clearly intended by the technical specifications of the relevant equipment/component, or provided in the Schedule of Prices, or specified in the Contract.

**vi. Witnessing of Factory Acceptance Tests / Inspections for Plant**

Factory acceptance tests / inspections for all E & M equipment shall be performed at original equipment manufacturer (OEM) facilities and each test / inspection shall be witnessed by three personnel of the Employer/ Engineer. All costs in connection with witnessing the factory acceptance tests by the Employer/ Engineer shall be borne by the Contractor and included in the cost of the relevant equipment.

These shall include the costs of air travel (economy class) from Pakistan to place of inspection/ testing and back, hotel accommodation / boarding/lodging (as per actual), inland transportation and daily allowance @ USD 150 per day per person for inspection/testing to be conducted outside Pakistan.

In case of local testing the daily allowance for the personnel witnessing the inspection and testing (Local FATs) shall be 10,000 PKR per day. All other facilities including travelling, lodging, transportation from the accommodation to the testing facilities and back will be Contractor's responsibility.

## **Different Manufacturing Processes**

### **vii. Steel Forgings**

The Contractor shall supply a list of all important forgings and draw up material specifications for each forging. Copies of this list and specifications shall be supplied to the Employer/ Engineer for his use. In each case the quality and inspection requirements shall be clearly stated.

Forgings shall be in accordance with the requirements of BS Standards 29, 970 or 4670, the equivalent ISO Standards, or agreed national Standards.

Test blocks from which mechanical test pieces shall be machined shall be cut from forgings at positions to be agreed by the Employer/ Engineer. On large and important forgings several test pieces shall be taken from radial and longitudinal directions.

Forgings shall be free from cracks externally or internally, extensive non-metallic inclusions and surface defects. The Contractor shall carry out non-destructive testing of forgings during machining to verify that no unacceptable defects are present.

Repairs by welding or other means shall not be undertaken on forgings at any stage of the production cycle.

Each forging shall be suitably branded with an identification number which shall be maintained throughout all final machining stages. The identification number shall be marked on all documents and test certificates related to the forging.

### **viii. Castings**

Test bars shall be provided from medium and large castings for all necessary material and chemical tests which are to be witnessed by the Employer/ Engineer.

If required by the Employer/ Engineer any castings for rotating or highly stressed parts are to be subjected to non-destructive testing by approved methods including radiographic and ultrasonic means, the cost of which shall be borne by the Contractor.

All castings shall be homogeneous and free of shrinkage, under sizing, porosity or voids. "Burn in" repairs are not acceptable and no welding, filling, interlocking or plugging of defective parts shall be done without the Employer/ Engineer's approval in writing. All repairs shall be subjected to non-destructive examination (ultrasonic, X-rays, gamma rays) after heat treatment. Welding repairs to castings that shall be in contact with corrosive liquids such as seawater or brine shall only be permitted under special circumstances.

**ix. Steel Castings**

The Contractor shall prepare material purchasing specifications for all important castings. Each document shall indicate the quality and inspection requirements for the component casting covered. Copies of the Specification shall be issued to the Employer/ Engineer for his use.

Castings may be repaired by welding only after approval by the Employer/ Engineer. The Contractor shall submit drawings, sketches or photographs and metallurgical test reports showing the location and principal dimensions of the defect together with the proposed weld repair procedure. The maximum size of defect for which weld repair shall be permitted is:

Maximum length of defect	20 mm
Maximum width of defect	10 mm
Maximum depth of defect	not greater than 10% of the wall thickness but in no case greater than 20mm

Only welders who have passed an appropriate qualification test shall be employed on the repair of castings. All repairs shall be carried out by the metal arc process.

Ultrasonic inspection shall be applied to all important castings to locate the extent of sub surface defects and to check the wall thickness.

All castings shall be identified by stamped, or cast on reference marks which shall be entered on all relevant documents and test certificates.

The Employer/ Engineer may require that certain castings shall be examined using radiographic techniques. The Contractor shall include for this eventuality and shall comply with the Employer/Engineer's instructions when issued.

**x. Cast Iron Castings**

Cast iron shall not be used for any part of equipment which is in tension or which is subjected to impact, or to a working temperature exceeding 200°C unless specifically approved by the Employer/ Engineer.

**xi. Aluminium Bronze Castings**

The inspection and quality requirements for Aluminum Bronze Castings shall include an analysis of each cast, mechanical testing of test bars from each cast, pressure testing, penetrant flaw detection and radiographic examination of selected critical areas.

Weldable grades of aluminium bronze may be repaired by welding after approval of Employer/ Engineer in accordance with the special provisions as given above.

On completion of repairs, welded areas shall be ground smooth and carefully blended into the parent material. The repaired areas shall be examined for defects using penetrant flaw detection and radiography. Crack like linear defects shall not be permitted.

**xii. Fabrications**

The Employer/ Engineer shall be notified at least two (2) days prior to commencement of any assembly or fabrication work on site.

The CO<sub>2</sub> and flux cored welding process shall not be acceptable for site welding.



**xiii. Materials**

The material shall be of highest grade free from defects and imperfections, of recent manufacture and unused.

All materials incorporated in the equipment supplied shall be of quality, grades and conditions as set forth in the approved Standards.

Materials not specifically designated herein shall be subject to the approval of the Employer/ Engineer, shall be suitable for their purpose and shall as far as practicable comply with the latest issue or revision of the designated standards or approved equivalent.

Materials for general purposes shall be delivered according to the following standards, or their equivalent. The grade used shall depend on stress levels, environmental conditions, resulting material thickness and manufacturing and inspection procedures.

The material grade shall be proposed by the Contractor, unless otherwise specified, but are subject to the Employer/ Engineer's approval.

**Table-1.3: Applicable Standards for Different Materials**

No.	Description	Standard / Code
1	Structural steel, general purpose	EN 10025, ASTM A36
2	Fine grained, normalized steel, general purpose	EN 10113
3	Fine grained, normalized steel, pressure vessels	EN 10028
4	Cast steel for general engineering purposes	DIN 1681, ISO 3755, ASTM A27
5	Cast steel for pressure vessels	EN 10213
6	Iron castings, nodular	DIN 1693, ISO 1083, ASTM A536
7	Steel forgings for generator rotors	ASTM A469
8	Turbine shaft steel	EN 10083, ASTM A668
9	Stainless steel, general purpose	EN10088, ASTM A240 & A269
10	Stainless steel castings general purpose	DIN 17445, ISO 683-13, ASTM A487
11	Babbitt metal	ISO 4381, ASTM B23

**xiv. Working Stresses****Loading**

Ample factors of safety shall be used throughout the design of the equipment, especially in the design of parts and components subject to alternating stresses, vibration~ impact or shock.

In general, the loading shall be divided into 3 different classes according to the following typical examples:

**Normal loading**

- Loading due to dead loads
- Hydrostatic loads, from vacuum to design water pressure

- External pressure
- Hydrodynamic loads, design values for surges and pressure rise
- Friction loads
- Forces due to temperature variations
- Environmental loads with a return period of 50 years
- Dynamic loads due to normal operation
- Speed rise at load rejections
- Vibration loads caused by flowing water or by ordinary operation

### Unusual loading

- Sediment loading, where appropriate, constructions shall be controlled for an increased load due to sedimentation
- Un-symmetric loading due to uneven frictional forces

### Extreme loading

- Earthquake loading
- Loading due to maximum (PMF) floods
- Vacuum in penstocks and steel linings
- Loading due to transportation and erection
- Emergency situations, complete short circuit forces in generator
- Emergency hoisting
- Continuous run away of the generating unit
- Pressure testing at 50 % above design pressure

The various loads shall be combined if physically possible, and the worst situation shall determine the design conditions. At unusual and extreme loading, each unusual or extreme load cases shall be combined with the most severe normal loading.

### Normal Design Conditions

The following stress levels at the different load cases are the maximum allowable values. Lower stress levels may be prescribed in the particular specifications for the individual sections of work, or under Construction Elements in these General Specifications, or in the various design standards used for particular components.

Under design conditions, the combined stress levels calculated according to Von Mises theory shall not exceed what is allowed according to the approved standards, but shall in no case exceed the following values unless otherwise stated by the Contractor and approved by the Employer/ Engineer.

**Table-1.4: Working Stresses**

Material	Stress Condition	Stress Limit
Structural steel materials	Maximum general stress level	67% of the yield strength
Structural steel materials	Average stress at points with local stress concentrations, calculated according to	75% of the yield strength, provided the quality of material can be confirmed by approved



Materials for pressure vessels, spiral casings, larger valve housings penstocks and similar which are heat treated after manufacture, shall have a critical crack length which shall cause the crack depth to penetrate the vessel, thus causing the vessel to leak without bursting at its lowest operating temperature and at the general maximum stress level. For vessels not heat treated, the same shall apply for stresses equal to the yield stress.

#### Pressure Testing

Before pressure testing of larger components the critical crack size shall be calculated and compared with the crack detection level. The general membrane stress in any part shall not exceed 80% of the yield stress.

#### Runaway Conditions

Under maximum runaway conditions, the increasing forces due to deformations under loading shall be considered.

#### Special design criteria for Shaft bending frequency

The following criteria shall be observed for main shaft systems (turbine/generator, pump/motor, diesel-engine/generator etc.):

- The 1 order shaft natural bending frequency shall exceed the maximum transient runaway speed with 20% or more. The shaft natural bending frequencies shall have a separation of 20% or more to the operating speed, to the line frequency (50 Hz) and to other predominant system frequencies.
- For auxiliary motors, pumps and other rotating equipment, the shaft speed shall not exceed 90% of the 1 order shaft natural frequencies at a temporary line frequency or 75 Hz.

Standardized electrically driven equipment rated less than 6 kW may, after approval by the Employer/ Engineer, be exempted from these criteria.

The deformations shall at all loads be within acceptable limits according to the best engineering practice.

The Contractor shall assume full responsibility for an adequate design and shall use lower stresses wherever necessary.

#### Earthquake loading

The earthquake loading shall be calculated using the specified horizontal and vertical acceleration, usually 10 to 30 % of the gravity acceleration. Dam gates and similar may be calculated from a parabolic pseudo-static loading.

#### xv. Machine Work

##### General

Sufficient machining stock shall be allowed on all parts to be machined to ensure true finished surfaces of solid material. Finished contact or bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished, and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. No machining shall be done on working surfaces of self-lubricating bushings or washers.

**Finished Surfaces**

In addition to the machined surfaces indicated on the Contractor's Drawings, all surfaces that require machining for their intended function and those surfaces that are normally machined in good shop practice shall be machined.

**Unfinished Surfaces**

All work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined, to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the Contractor's Drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in an approved manner. Corrosion-resistant-steel, seal plate surfaces in contact with seals shall be thoroughly cleaned to have a smooth and even surface.

**Assembly**

Before assembly, all bearing surfaces, journals, and grease and oil grooves shall be carefully cleaned and lubricated with an approved oil or grease. Solvents shall not be used on self-lubricating bearings. After assembly, each lubricating system shall be filled with an approved lubricant. Self-lubricating bearings shall not be greased and shall be assembled dry according to the manufacturer's instructions.

**Surface Finish**

The quality of all surface finishes shall be selected with due regard for the nature and function of the surface and in accordance with conservative design practice. Surface finish shall be subject to the Employer/ Engineer's approval.

**xvi. Material Tests and Inspection****Mechanical Properties**

Material tests are required on all materials used for the Plant. Certified mill sheets may be accepted to the approval of the Employer/ Engineer. Otherwise the Contractor shall conduct independent tests to establish chemical and mechanical properties, in accordance with the specified Standards.

Materials shall be tested for conformity with the methods specified in ASTM A370 "Methods and definitions for mechanical testing of steel products". Where these Specifications or Standards require impact testing or impact testing is an option, ferrous materials and fabrications shall have a Charpy value greater than 35 Nm at -20°C. This shall include all items subject to full penstock pressure and used for pressure vessels.

**Forgings**

Forgings shall be ultrasonically examined in accordance with ASTM A388M "Practice for Ultrasonic Examination of Heavy Steel Forgings". Magnetic particle examination shall be in accordance with ASTM A275M "Test Method for Magnetic Particle Examination of Steel Forgings".

## Castings

Castings for fabrications designated as pressure vessels or subject to full penstock pressure shall be radio graphically examined for flaws in accordance with ASTM E1030 "Test method for the radiographic examination of metallic castings". Evaluation of radiographs shall be to the following Standards:

- ASTM E446 "Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness"
- ASTM E186 "Reference Radiographs for Heavy-Walled (2 to 4½ in. (51 to 114 mm)) Steel Castings"
- ASTM E280 "Reference Radiographs for Heavy-Walled (4½ to 12 in. (114 to 305 mm)) Steel Castings"

Magnetic particle and liquid penetrant inspection shall be conducted to ASTM A903 / A903M - 91 "Specification for Steel Castings, Surface Acceptance Standards, Magnetic particle and Liquid Penetrant Inspection".

Castings shall be free from injurious defects and shall be satisfactorily cleaned for their intended use. Surfaces of castings which are not machined shall be dressed for good appearance and for painting. The location of existing defects shall be determined, and all defects which impair the strength or utility of the casting shall be removed to sound metal before repair. The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a casting shall be rejected.

Castings shall be inspected visually at the foundry after they are cleaned and while defects are being removed. Castings shall also be inspected after repairs and after heat treatment. Radiographic or other non-destructive tests shall be required as specified and as directed when permission is granted to repair major defects. The Employer/ Engineer reserves the right to require non-destructive tests at the Contractor's expense to determine:

- The full extent of defects,
- That the area is properly prepared for welding, and
- That the repairs are satisfactory.

## Repair Welding

Minor defects that shall not impair the strength or serviceability of the castings may be repaired by welding in accordance with accepted foundry practices without review by the Employer/ Engineer. Defects shall be considered minor when the depth of cavity properly prepared for welding is not greater than 25% of the actual wall thickness but in no case greater than 20 mm, and when the area to be welded is smaller than 50 cm<sup>2</sup>.

However, an accumulation of minor defects which in the opinion of the Employer/ Engineer casts doubt as to the general quality of the casting shall be considered as a major defect. A complete descriptive report of each major defect, supplemented with sketches, photographs, and metallurgical test reports, as the case may warrant, and the proposed repair procedure shall be submitted for review prior to any repair of major defects. If removal of defects reduces the stress-resisting cross-section of the casting by more than 30%, the casting may be rejected. All castings repaired by welding of major defects after heat treatment shall be heat treated again.

## Dimensions

Dimensions of castings shall not be reduced due to shop or foundry practices by an amount sufficient to impair the strength of castings by more than 10% (calculated from Contractor's Bid Drawing dimensions). Dimensions shall not be oversized to the extent that a casting interferes with processing operations or proper fit with other parts. Warped or otherwise distorted castings shall not be used.

## Steel Plates

Steel plates for fabrications designated as pressure vessels subject to full penstock pressure as designated in these Specifications shall be ultrasonically examined in accordance with ASTM A435 / A435M - 90 "Specification for Straight-Beam Ultrasonic Examination of Steel Plates for Pressure Vessels".

## Welds

The extent of non-destructive testing of welds is specified in these Specifications.

Radiographic examination of welds shall be in accordance with Paragraph UW-51 of Section VIII of the ASME "Boiler and pressure vessel code". Radiographs of welds shall be evaluated by comparison with reference radiographs conforming to the requirements of ASTM E390 "Reference Radiographs for Steel Fusion Welds".

Ultrasonic examination of welds shall be in accordance with paragraph UW 53 of Section VIII the ASME Boiler and Pressure Vessel code.

Magnetic particle and dye penetrant examination of welds shall be in accordance with the relevant ASME and ASTM Specifications.

## Surface Treatment and Painting

### xvii. General

The specifications for the surface treatment given below are based on the conditions and environmental data available at the time the Tender Documents are issued. The Engineer reserves the right to prescribe improvements on such treatment, should the available information and operational conditions prior to manufacture deem it necessary.

The Contractor shall provide a complete and reliable surface treatment of the equipment furnished. Such work shall include the workshop and site coating up to and including the finishing painting.

Unless otherwise specified, the coating and painting shall be carried out in accordance with these specifications and ISO 12944, "Corrosion Protection of Steel Structures by Coating System", or other equivalent standard.

The Contractor shall, however, in all respects fulfill the requirements imposed by the site conditions, such as the quality of water, climatic conditions and other environmental conditions which may in any way affect the quality and suitability of the surface protection. The quality shall in all respects ensure long-life protection of the equipment, and due consideration shall be given to the fact that the Plants, to a large extent, will be difficult to maintain once they are taken into use.

The Contractor shall submit for the Engineer's approval full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the structures, machinery and equipment during transport, site storage, building and concreting and subsequent erection, and the extent to which blast-cleaning, priming and painting will be carried out in his workshop (or his subcontractor's, as the case may be), at the site and after erection.

The Contractor shall ensure that the materials, methods and sequences he proposes to use comply with relevant safety rules and health standards, and does not contaminate the environment.

The Contractor shall submit full details of materials including volatile matter content, nature of solvent, number of components, type of coat, specific coverage, time interval between coats and number of coats, compatibility of each coat with the previous coat, toxic properties, physical properties, shelf life, pot life, resistance against chemical attack, resistance against ozone and UV-radiation, compatibility with drinking water standards, etc.

Coating materials shall be standard products of a reputable manufacturer with proper experience in the field of corrosion protection of the type of equipment to be supplied. The material shall apply to relevant standards, and test results may be requested. In particular, the products used for Protection System No. 1 shall have been tested for at least 1 year according to ISO 2812-2, Water Immersion Test, without any failure.

Blasting and coating shall, as far as possible, be applied after the structures and components are welded and machined. Equipment which cannot be blast-cleaned after the last machining shall, prior to the machining, be blasted, primed and given one top coat. Before any coat is applied, the surfaces shall be properly prepared. Such preparation includes any cleaning, drying and similar operation that may be required to ensure that the coating is applied to a suitable base. All blasting and coating shall be completed at least 200 mm beyond concrete boundaries where parts are embedded.

Temporary protection of steel materials, prior to, and during production, or during transportation, is not included in this specification.

Components of stainless steel shall in general not be painted or galvanized.

**Table-1.5: Steel Structures, Protection Systems**

PRE-TREATMENT	SURFACE TREATMENT	PAINTING SYSTEM	PAINT
<b>SYSTEM 1: SURFACE IN CONTACT WITH WATER</b>			
Remove all grease, salts and other contaminations with water miscible detergent and high pressure fresh water	Abrasive blasting to Sa 2 ½ according to ISO 8501-1 (SSPC SP 10) with a sharp-	<b>FIRST COAT</b> Two component, high solids, low VOC, surface tolerant epoxy coat	160µm Interseal 670 HS or equivalent



PRE-TREATMENT	SURFACE TREATMENT	PAINTING SYSTEM	PAINT
washing or/and solvents according to SSPC.	edged grit. Surface roughness Rz = 50-75 µm.	<b>INTERMEDIATE COAT:</b> Two component, high solids, low VOC, surface tolerant epoxy coat	180µm Interseal 670 HS or equivalent
		<b>TOP COAT:</b> Two component, high solids, low VOC, surface tolerant epoxy coat	160µm Interseal 670 HS or equivalent
		<b>NDFT</b>	<b>500µm</b>
<b>SYSTEM 2: SURFACES EXPOSED TO AIR</b>			
Remove all grease, salts and other contaminations with water miscible detergent and high pressure fresh water washing or/and solvents according to SSPC.	Abrasive blasting to Sa 2 ½ according to ISO 8501-1 (SSPC SP 10) with a sharp-edged grit. Surface roughness Rz = 50-75 µm.	<b>PRIMER:</b> Two component zinc rich epoxy primer	70 µm Interzinc 52 or equivalent
		<b>INTERMEDIATE COAT:</b> two component, high solids, low VOC, modified epoxy coat	180 µm Intergard 475 HS or equivalent
		<b>TOP COAT:</b> two component, high gloss and color retention, high performance acrylic polyurethane coat	50 µm Interthane 990 or 990 SG or equivalent
		<b>NDFT</b>	<b>300 µm</b>
<b>SYSTEM 3: SURFACES EXPOSED TO OIL</b>			
Remove all grease, salts and other contaminations	Abrasive blasting to Sa 2 ½ according to	<b>PRIMER:</b> Two component,	125 µm Interline 850 or

PRE-TREATMENT	SURFACE TREATMENT	PAINTING SYSTEM	PAINT
with water miscible detergent and high pressure fresh water washing or/and solvents according to SSPC	ISO 8501-1 (SSPC SP 10) with a sharp-edged grit. Surface Roughness Rz = 50-75 µm. Allowable oil qualities: mineral oil according to DIN 51515	chemically resistant, high solids, high build epoxy coat  <b>TOP COAT:</b> <b>Two component, chemically resistant, high solids, high build epoxy coat</b>	equivalent  <b>125 µm</b> <b>Interline 850 or equivalent</b>
		<b>NDFT</b>	<b>250 µm</b>
<b>SYSTEM 3.1: SURFACES EXPOSED TO OIL – UNPAINTED</b>			
Remove all grease, Salts and other contaminations with water miscible detergent and high pressure fresh water washing or/and solvents according to SSPC.	First: Abrasive blasting to Sa 3 according ISO 8501-1 (SSPC-SP5) Second: grinding to smooth surface profile of Ra, max. = 3,2 µm	<b>COAT:</b> Solvent cutback, wax base, corrosion preventive compound <b>(choose one)</b>	35 µm Chesterton 740 or equivalent  35 µm Tectyl 506 or equivalent  35 µm LPS 3 or equivalent
<b>SYSTEM 4: MACHINED CONTACT SURFACES</b>			
Remove all grease, salts and other contaminations with water miscible detergent and high pressure fresh water washing or/and solvents according to SSPC.		<b>COAT:</b> Quick drying, two component, epoxy holding primer	20 - 40 µm Intergard 269 or equivalent
		<b>NDFT</b>	<b>20 - 40 µm</b>

PRE-TREATMENT	SURFACE TREATMENT	PAINTING SYSTEM	PAINT
<b>SYSTEM 4.1: MACHINED SURFACES IN EXPOSED TO AIR</b>			
Remove all grease, salts and other contaminations with water miscible detergent and high pressure fresh water washing or/and solvents according to SSPC.		<b>COAT:</b>	20 - 40 µm
		Quick drying, two component, epoxy holding primer	Intergard 269 or equivalent
		<b>NDFT</b>	<b>20 - 40 µm</b>
<b>Notes:</b>			
Machined surfaces shall not be blast cleaned or grinded.			
After final assembly, the surfaces shall be treated according to SYSTEM 2 (intermediate and top coating to be applied)			
<b>SYSTEM 4.2: MACHINED SURFACES – UNPAINTED</b>			
Remove all grease, Salts and other contaminations with water miscible detergent and high pressure fresh water washing or/and solvents according to SSPC.	First: Abrasive blasting to Sa 3 according ISO 8501-1 (SSPC-SP5)	<b>COAT:</b>	35 µm
	Second: grinding to smooth surface profile of Ra, max. = 3,2 µm	Solvent cutback, wax base, corrosion preventive compound <b>(choose one)</b>	Chesterton 740 or equivalent
			35 µm
			Tectyl 506 or equivalent
			35 µm
			LPS 3 or equivalent

## Welding General Requirements

### xviii. Site Welding

Designs shall be such as to minimize Site welding.

Unless otherwise stated the qualification of welding procedures, welders, and welding operations, including weld repairs of castings shall conform to Section IX of the ASME "Boiler and Pressure Vessel code".

Unless otherwise stated all welded parts shall be designed, fabricated, inspected and tested in accordance with Section VIII of the ASME "Boiler and Pressure Vessel code" and shall be stress relieved prior to machining in accordance with the requirements of the same code. For certain structural items welding, welders and weld procedure may be in accordance with AWS Standards. These items shall be identified in these Specifications. All pressure vessels and items subject to penstock pressure shall be welded as per relevant sections of ASME.

Welds shall in general be treated so that they shall display good appearance and a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. All welds which require non-destructive examinations shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination methods.

All welds shall be continuous, watertight and free from voids.

Welded-on fabrication aids shall be kept to a minimum. They shall be attached only by approved welders and shall be removed by flame cutting not less than 1.5 mm above the parent plate surface and then by subsequent grinding and crack detection of the weld area.

All plate butt welds shall be full penetration back gouged and welded from both sides.

The minimum size of fillet welds shall be 6.5 mm measured on the leg. Undercutting not exceeding 1 mm shall be removed by grinding. Undercutting exceeding 1 mm shall be filled by welding.

The edges of surfaces (up to the thickness of the metal) to be welded shall be of sound metal free from visible defects such as laminations or defects caused by cutting operations and free from rust, oil grease and other foreign matter.

#### **xix. Weld Procedure Qualification Tests**

Weld procedure qualification tests shall be carried out in accordance with the requirements of BS EN 288 or agreed International Standard for the item of Plant under consideration.

Providing that the Contractor confirms that the basic parameters of the procedure have not been changed since approval, the results of weld procedure qualification tests previously carried out under the supervision of any internationally recognized inspecting authority may be accepted by the Employer/ Engineer.

The Contractor shall inform the Employer/ Engineer of any proposed changes to the welding procedures before such changes are implemented. If in the opinion of the Employer/ Engineer a further qualification test is required as a result of such changes, then the Contractor shall perform the required test without additional charge.

The results of all tests shall be made available, for examination by the Employer/ Engineer, if required.

#### **xx. Welder's Qualification Tests**

All welder's and welding operators shall be qualified for the work and shall hold welders qualification certificates from Pakistan Welding Institute or other accredited organization as approved by the Employer/Engineer in accordance with BS EN 287, BS 4872 or agreed International/Local Standard for the work.

All Welders tests shall be witnessed and/or approved by the Employer/ Engineer before the welder or operator is permitted to work. In addition the Contractor shall arrange for the welders tests at site to be approved by the Employer/Engineer using a local consultant or third party inspector, if necessary. The decision of the Employer/ Engineer regarding the acceptability of any test or existing qualification tests shall be accepted solely at the discretion of the Employer/ Engineer.

Records showing the date and results of the qualification tests performed by each welder and

weld operator together with the identification number assigned to him shall at all times be available for scrutiny by the Employer/ Engineer.

**xxi. Storage of Welding Consumables**

Welding consumables shall be stored in a manner that shall protect them from all forms of deterioration prior to use and shall be properly identified.

Gas cylinders for use with burning or welding equipment shall be marked in accordance with the requirements of BS 349 (ISO/R448). Site storage procedures for gas cylinders shall require the approval of the Employer/ Engineer.

**xxii. Visual Weld Inspection**

Each weld shall be subjected to a stringent visual inspection and shall be free from undercut, excessive spatter, craters, cracks, porosity and other surface imperfections. Welds shall be of regular contour, even weld ripple and indicative of good workmanship.

Fillet welds shall be checked for dimensional tolerance using a fillet weld gauge. Fillet welds should be slightly concave in form and each leg of the weld shall have equal length.

**xxiii. Internal Examination**

The internal root bead of tube butt welds shall be examined by intra-scope or other suitable optical device.

**Non Destructive Examination**

All non-destructive examinations shall be supervised by a fully qualified and experienced specialist appointed by the Contractor. Individual operators in each of the respective techniques shall be qualified and trained in the respective subject and shall have reached a standard comparable with the Certification Scheme of Weldment Inspection Personnel in the United Kingdom.

Testing shall be in accordance with the requirements of BS 709 "Methods of Testing Fusion Welded Joints and Weld Metal in Steel" or an agreed National Standard.

**xxiv. Radiography**

The Contractor shall be responsible for all Radiography Inspections works to be involved in the Contract. Radiography shall be carried out in accordance with the requirements and recommendations of the appropriate British or other National Standards Authority (PWI) with agreement by the Employer/Engineer.

**xxv. Manufacturer's Works**

Radiographic inspection at manufacturer's work shall be accomplished with X-ray equipment throughout.

**xxvi. Site Testing**

Gamma radiography shall be permitted only in appropriate cases at the job Site. Cobalt 60 sources shall not be used for site testing without the express permission of the Employer/ Engineer in writing. Should the Contractor bring in radiography equipment from outside Pakistan, the Contractor shall be responsible for legal and customs clearance.

**xxvii. Techniques**

Radiographic techniques shall be in accordance with BS 2600 Parts 1 and 2 BS 2910 and other relevant British Standards or agreed National Standards.

The Contractor shall take all possible steps to protect radiographic and all other personnel from the effects of ionising radiation.

**xxviii. Ultrasonic Examination**

Ultrasonic examination of welds shall be carried out in accordance with BS 3923 Part 1 Part 2 and any other relevant British Standards or agreed National Standards with agreement by the Employer/ Engineer.

**xxix. Magnetic Crack Detection**

Magnetic crack detection shall be carried out in accordance with BS 6072 or an agreed National Standard.

**xxx. Dye Penetrant Tests**

Dye penetrant tests shall be in accordance with BS 6443 or any other relevant British or agreed National Standards.

**xxxi. Quality Requirements for Welds**

All welds subjected to non-destructive tests shall be entirely free from cracks or crack like defects, lack of root fusion, lack of sidewall fusion, root burn through, or tailed pores. The standard for porosity and slag inclusions shall be as indicated in the agreed standards for design and welding.

**xxxii. Weld Repairs**

The Employer/ Engineer's approval shall be obtained prior to commencement of any repair or rectification work.

Weld repairs shall be made to the same procedure as for the original weld. All tests shall be repeated after the repair has been completed and reports on radiographic and ultrasonic tests shall be marked to indicate that the report refers to a repaired weld.

**xxxiii. Mandatory Inspections**

All transition welds between dissimilar materials, such as high alloy steels to carbon steel, or austenitic steels or nonferrous materials to steels, shall be subjected to 100% ultrasonic examination or crack detection wherever practicable. In addition, all butt welds between dissimilar materials shall be subjected to 100% radiographic examination.

All welds in ferrite alloy steels, e.g. having a carbon equivalent value in excess of 0.40%, and high yield strength steels, e.g. having yield strength greater than 300 MPa, shall be subjected to 100% ultrasonic examination and crack detection wherever possible. In addition, all butt welds in these materials shall be subjected to 100% radiographic examination.

A minimum of 10% of all butt welds on all classifications of work shall be radio graphically examined, unless otherwise as advised by Employer/ Engineer.

## **Piping**

Pipe work drawings shall be in accordance with ISO 6412.

Piping shall be arranged to facilitate access for maintenance and such that removal or replacement of Plant can be achieved with the minimum dismantling of piping. The design of piping shall be such as to minimize Site welding.

All pipes work 25 mm and below shall be stainless steel or copper.

Provision shall be made for the draining and release of air in systems. Plugged drain and air release bosses shall be welded to pipes at appropriate points to facilitate hydraulic testing.

All interior water pipes shall be lagged with fiberglass lagging not less than 1" or equivalent suitable insulation material as approved by the Employer/ Engineer.

Embedded pipe should be kept to a minimum. In preference to running pipe in covered floor trenches it shall be supported from walls and ceilings.

Floor collars or wall box shall be provided at all points where pipes pass through floors and walls. The floor collars shall have raised kerbs not to be less than 75 mm in height. All wall boxes shall be sealed and flush fitting.

The Contractor shall provide all necessary fittings for the passage of pipes through external walls and roofs, together with all necessary components for the protection against weather.

In the case of flanged pipe work, boxes shall be large enough to permit the passage of the flange.

### **xxxiv. Identification of Piping**

The Contractor shall furnish and apply pipe identification markers on all piping systems. The markers shall be applied after all insulation and painting work has been completed. Each pipe shall be identified at each valve, at every point of pipe entry or exit where two or more lines go through a wall, at each tee joint, and on continuous lines, at least once in every unit block.

A direction of flow marker shall be affixed downstream of each pipe identification marker. Markers shall be applied on the two lower quarters of the pipe where the view is unobstructed. The markers shall be of adhesive-coated vinyl cloth which shall be applied in accordance with the manufacturer's instructions, and shall be white with black letters. Letters shall vary between 10 mm and 40 mm in height to suit the piping size. Pipe marker legends shall be placed on walls and other suitable areas as designated by the Employer/ Engineer.

### **xxxv. Pipe Welding**

Pipe work welding, testing and inspection shall conform to the appropriate ASME and ASTM Standards and applicable AWS.

### **xxxvi. Hydrostatic Testing**

Except as precluded by shipment in parts for Site welding due to size, hydrostatic works tests shall be carried out by the Contractor on all casings, vessels, valves, pipes and other pressure fittings. Such tests shall be at 50% above the maximum operating pressure or 4.5 bar whichever is higher. The test pressure and date shall be stamped on all parts tested and certificates or written particulars of each test shall be supplied to the Employer/ Engineer.

In each case the pressure shall be maintained for a period of thirty minutes, the item under test remaining tight under the specified pressure.

All valves shall be tested for both "open end" and "closed end" conditions.

All piping systems shall be hydrostatically tested at Site.

#### **xxxvii. Pipe Supports and Anchors**

Pipe work and accessories shall be supported and mounted in accordance with ANSI B31.1 Power Piping. All necessary slings, saddles, structural steelwork, foundation bolts, foundation inserts and plates, fixing bolts, locks and all other attachments shall be supplied.

No point of passage of pipes through floors or walls shall be used as a point of support.

#### **xxxviii. Flanges**

All pipe flanges, shall be in accordance with ISO 7005 Standard as applicable for the appropriate condition. Threaded pipe shall be in accordance with ISO 7 and ISO 228 as applicable.

#### **xxxix. Jointing Material**

Complete jointing material, bolts, nuts and washers shall be provided for flanged pipes, valves and fittings supplied under this Contract. Threads and other details of fasteners shall comply with ISO Standards. The quantities supplied shall include twenty per cent excess to allow for wastage.

#### **xi. Internal Cleaning of Pipes**

The Contractor shall ensure that the internal surfaces of all pipelines are thoroughly cleaned by air purging and water / hydraulic oil flushing whatever is applicable.

All internal surfaces prior to erection shall be cleaned to remove accumulations of dirt, rust, scale, and welding slag due to Site welding before erection.

Prior to and during erection, all parts shall be inspected to make sure that they are clean, and adequate steps shall be taken to prevent entry of foreign matter both during and after erection. Each section erected shall be cleaned out before the next section is connected to it. All headers shall be cleaned before closing up.

All ferrous oil pipe work shall be acid pickled and flushed with oil prior to erection.

All pipe work after erection shall be flushed using the same fluid as for the system.

The Contractor shall provide all necessary facilities in the pipe system for cleaning including any temporary pipe work.

#### **xii. Pipe Terminations and Connections**

The Contractor shall co-operate fully with other Contractors and the Employer/ Engineer to establish agreement on the jointing technique at terminal points.

All pipe connections shall be fusion welded except where flange connections are required or specified to facilitate erection or maintenance, or where pipe materials used preclude welding.



Screwed pipe work shall only be permitted for pipes of less than 50 mm bore in non-critical air or water services.

Below 25 mm bore connections may be of compression type couplings in positions where leakage shall not introduce any hazard and the type of coupling and particular application has been approved by the Employer/ Engineer.

Pipe work flanges shall comply with the requirements of the code to which the pipe work is designed. Flanges having ratings less than 10 bar shall not be permitted except where agreed with the Employer/ Engineer.

All metallic pipe flanges either for high or low pressure or for high or low temperature shall be in accordance with ANSI/ASME B16.5, and other approved standards, as applicable for the appropriate condition.

All plastic pipe flanges shall be in accordance with ISO 2536 and 3663 and the other standards issued by Technical Committee 138 (TC138) of the International Organisation for Standardization.

Jointing material, bolts, nuts and washers shall be provided where necessary for flanged pipes, valves and fittings supplied under this Contract.

In the case of cast iron flanges full face gaskets shall be used so that bending stresses shall not be induced in the flange by bolt tightening.

Jointing of thermoplastic piping shall be carried out in strict accordance with the Manufacturer's recommendation.

### xiii. Fluid Velocities in Pipes

The maximum allowable velocity of flow in pipes shall be as listed in the following table:

**Table-1.6: Maximum Allowable Flow Velocity in Pipes**

<b>Service</b>	<b>Maximum Allowable Velocity (m/s)</b>
Compressed air	15
Cooling water	3
Lubricating Oil	2
All other pipe work	0.6 m/s per 25 mm bore up to a maximum of 4.2

Higher values may be approved in special applications or for systems used intermittently.

Notwithstanding the maximum velocities permitted above, the noise levels in the pipe work systems shall comply with the appropriate clauses of the Specification.

### xiv. Buried Pipe Work

All buried pipe work shall be of stainless steel except Penstocks.

## **xv. Valves**

### **General**

All valves shall comply with the relevant ISO Standards.

All valves shall be arranged so that the hand wheel moves in a clockwise direction to close the valve. The face of each hand wheel shall be clearly marked with the words "open" and "close" and shall be provided with an arrow to indicate direction for opening and closing. As far as possible, valves shall not be fitted in an inverted position.

All valves shall be readily accessible for both operating and maintenance and, where necessary for ease of manual operation, the spindles shall be extended and an approved form of pedestal hand wheel provided at convenient operating floor or intermediate floor level.

All hand operated valves shall be capable of being opened or closed against their maximum working pressure with a force at the hand wheel not exceeding 200 N.

All valves shall be fitted with labels showing duty and identification number.

All hand wheels shall be of metal. Bonnets and valve covers shall be bolted in position, not screwed.

Valves used for isolation purposes shall not be smaller than the pipeline size.

A complete valve schedule for each pipe work system shall be provided for approval.

Parallel slide ball or gate valves may be used for isolation purposes for water, oil and gas services. In general valves shall not be used for throttling service. Flow control shall be achieved by stainless steel orifice plate mounted between flanges for ease of adjustment. To the approval of the Employer/ Engineer needle valves may be used for throttling services in special cases. Butterfly valves shall not be used for flow control.

Parallel slide or gate valves shall be such that the bore of the fully open valve is unobstructed by any part of the gate.

Non return valves shall be of the non-slam type. Safety relief valves shall be of the pop action type.

### **Globe Valves**

Globe valves shall generally be used for regulating purposes. The valve shall preferably have spherical sealing and the disc shall be free to revolve on the spindle. An arrow indicating the direction of flow through the valve shall be clearly cast or embossed on the body of each valve.

Globe valves shall comply with BS 5154 or BS 5160 or equivalent as might be applicable to the particular installation requirement.

### **Safety Relief Valves**

Pressure relief valves shall be of the spring-loaded type unless otherwise specified, or unless the Employer/ Engineer has given written permission for the use of a different type of valve actuation.

Safety valves shall comply with BS 6759 or equivalent.

Spring loaded valves shall be fitted with easing gear which shall not be extended.

Where necessary relief valves shall be supplied with vent pipes, silencers and drains, and with gagging equipment for hydraulic testing following erection and in the long term maintenance of the plant.

### **Butterfly Valves**

Butterfly valves shall have bodies of either the flanged or lugged wafer type. The actuator/manual gearbox shall be mounted direct to the valve body, other than where both actuator and body are fitted with feet for pedestal mounting; no actuator loads shall be transmitted via the pipe work. The valve should be mounted with spindle set horizontal. If the valve is designed for unidirectional flow, an arrow shall be cast or embossed in a prominent position on the valve body to indicate the flow direction. The valve must be capable of positive shut off in the direction of flow against full system pressure.

### **Pressure Reducing Valves and Relief Valves**

Pressure reducing valves shall be of the external pilot valve operated type capable of passing the required total flow while operating over the same head range as the turbine. The minimum discharge head shall include a generous margin to overcome the total losses of the raw water system and discharge to the tailrace. It shall be complete with all necessary fittings. The pressure reducing valve shall be designed to close reliably on cessation of flow. A relief valve shall be provided, designed to open at 10% overpressure and pass full flow at 25% overpressure.

## **xvi. Power Operated Valve General Requirements**

Valves, dampers and similar devices requiring abnormal physical effort to operate or high speed operation, shall be provided with powered actuation. Hand operating equipment shall also be fitted for closing and opening, which is effectively decoupled during power operation.

Electric actuators for on/off duties shall be fitted with travel limiting devices capable of accurate and positive adjustment. Torque limiting or other devices shall be provided to prevent damage to the mechanism in the event of jamming of the driven device.

All powered valve or damper mechanisms shall be provided with accurate indication of the position of the driven device.

Direct solenoid operation of valves shall comply with the requirements of the Control and Instrumentation Specification.

## **xvii. Valve Actuators**

Where specified, valves shall be provided with electric motorized actuators.

As far as possible, the actuators shall be the standard products of a well-known specialist manufacturer.

## Design and Construction

Actuators shall be of water tight, dust tight and hose proof construction to BS 2817 and IP 65 to IEC 60529.

All actuators shall be designed to open and close their respective valves at the maximum possible differential working pressure and maximum flows. Both valve and actuator shall be capable of withstanding without damage the maximum stall torque which may be generated by the actuator motor.

There shall also be a facility for manually operating each actuator and a safety interlock must be provided to prevent the motor from being energized whilst the manual drive is engaged.

Means must also be provided for padlocking the valve to prevent either manual or power operation during overhaul or maintenance activities on other parts of the Plant.

The electrical components of each actuator shall be housed in a weather proof watertight enclosure with an internal anti condensation heater. A separate terminal compartment shall be provided so that electrical components shall remain sealed during site wiring.

## Performance

The actuators shall be rated for three successive open and close stroke cycles of the valve or 15 minutes continuous operation under an ambient temperature condition of 60 °C maximum. They shall be capable of generating an unseating torque at least 50% in excess of the required valve seating torque without resorting to usage of any mechanical "hammer blow" device. The speed of operation of all power operated valves is to be selected to suit the operating conditions of the system and to minimize pressure surges.

## Protection

Each actuator shall be provided with a motor thermostat and a phase discriminator to guard against single phase failure or incorrect rotation. An alarm relay shall be provided in each actuator to activate a remote alarm in case of the valve being inoperable due to the motor thermostat operating, the control circuit fuse blowing, the phase discriminator operating, the local changeover switch being in the "LOCAL" position, or the local "STOP" button being depressed.

## xviii. Pumps

### Centrifugal Pumps and Fans

Centrifugal pumps sets shall be designed, manufactured, erected and tested in accordance with the applicable ISO Standards.

All centrifugal pumps shall be designed for continuous operation unless otherwise specified.

Centrifugal pumps shall be installed in positions convenient for operation and servicing. Where multiple centrifugal pump installations are required, each pump and its associated equipment shall be arranged in such a manner as to permit easy access for operation, maintenance and pump removal without disrupting Plant operation.

If several centrifugal pumps are used for the same pumping work, these shall be interchangeable.

Unless otherwise specified, all centrifugal pumps shall be designed to withstand 1.5 times the centrifugal pump zero flow pressure under maximum suction pressure conditions.

Pumps shall be sized to ensure that the net positive suction head available under the best favorable operating conditions shall be adequate for the type of pump employed.

All pumps and fans shall be tested at the Contractor's works. Pump performance tests shall be conducted in accordance with ISO 3555.

### **General Requirements of Centrifugal Pumps**

Preventive and routine maintenance time should be minimized by the selection of appropriate designs of pump, preferably those that leave casing to piping joints intact, i.e. horizontal split casing types for large centrifugal pumps and horizontal, back pull out types for smaller units. Where a significant saving in floor space or improvement of layout can be demonstrated, a vertical pump may be acceptable.

All pumps above 120 kW shall be provided with temperature sensors on the bearing of the pump and the motor. Vibration sensors shall also be fitted on pumps above 120 kW.

Pumps shall be capable of continuous operation with minimum maintenance over the operating range from minimum flow to maximum flow. The Contractor shall define this range. The rating of the driver and the pumps net positive suction head (NPSH) requirements shall be such that the pump is capable of a flow rate 10% in excess of the maximum flow rate required. In addition pumps shall be designed to have a reasonable margin on head (normally 5% on head for clean fluids, 10% for solids bearing fluids) to compensate for normal wear of pump components. There shall be an adequate margin on NPSH, normally greater than 1 m for values of NPSH required and between 2 m and 12 m with flow rates up to the stated maximum.

When pumps are installed to operate in parallel, they shall be capable of equal load sharing throughout the operating range. This implies a pump head flow characteristic that falls continuously from shut valve to duty point by at least 10%.

The pump unit shall, when operating over its normal range of flow rates, comply with the noise emission requirements stated in this Specification.

All pump motor units shall be installed on a substantial base plate, with isolating valves, a discharge non return valve, air release valves (for both pump casing and seal chamber), drain valves, suction and discharge pressure gauges unless otherwise stated. The supplier should review the minimum flow rates stated and advise if a leak off system is necessary, in which case all minimum flow detection devices, diversion valves and pipe work shall be supplied.

### **Technical Requirements of Centrifugal Pumps**

In selecting bearing type, account should be taken of possible vibration damage to the bearing surfaces while the machine is stationary. Where sleeve bearings are used, bearing shells shall be replaceable without removing pump or motor shaft. Bearing housings shall be effectively

sealed against loss of lubricant and ingress of fluid or dirt. Oil seals shall be replaceable without major dismantling of the pump.

All oil lubricated bearings shall have housings fitted with means of drainage, visual oil level indicator and capped filler or a constant level oiler which is accessible whilst the unit is operating. Grease lubricated bearings shall be connected to readily accessible greasing points either singly or at a battery plate. Lubrication should be by means of a pressure gun.

Where rolling contact bearings are used, they shall be sized to provide a minimum life of 16,000 hours (as per ISO Standard 281/1) under conditions of maximum load on the bearings. In the case of a close coupled pump, this requirement applies to the motor bearings.

The pump shafts shall be designed such that the first critical speed of the pump is at least 20% higher than the maximum speed encountered in service.

All rotating components shall be dynamically balanced and the complete pump shall comply with the requirements of the vibration section of this Specification.

#### **xix. Shafts, Seals and Couplings**

The pump shall be fitted, depending on its duty with a packed gland or mechanical seals of a reputable manufacturer, preferably of a pressure balanced type. The design of the unit shall allow the mechanical seal to be replaced or the gland to be repacked without disturbing the pump or driver. Any leakage at the gland shall be intercepted by a flinger.

All pump glands shall be provided with trays and guards to catch leakage. Piping shall be fitted for drainage to an approved location.

Other than on small pumps (i.e. with driver less than 50 kW) auxiliary pipe work for seal harnesses, drains, etc. shall be not less than 20 mm bore.

Couplings shall be dynamically balanced and the couplings shall be match marked. Where a spacer coupling is used, the spacer shall similarly comply.

#### **xx. Pump Materials**

Materials of construction shall be selected with due regard to the corrosive nature of the pumped fluid and risk of corrosion, cavitation, and metal to metal galling that can occur within a pump in all its modes of operation. It is the Contractor's responsibility to select materials that shall provide an adequate service life.

#### **Noise**

The Plant shall be designed and constructed to operate within the following noise limits:

- Within the building or structure containing the Works not exceeding ISO 1996 level NR 90 between 62.5 and 8000 Hz.
- Within control rooms not exceeding ISO 1996 NR 50 between 250 & 2000 Hz.

Noise levels shall be measured by the Contractor during commissioning of the Plant.

If the noise level of the Plant is found to be more than the specified limits, the Contractor shall take necessary measures and carry out any modification/additions to the Plant to meet the requirements of these Specifications.

## Vibration and Balance

The amplitude of vibration of rotating Plant when measured on the bearing housings under steady state conditions at the designed operating speeds shall not exceed the values given by the 2.8 mm/s criterion of ISO 3945.

Provision shall be made for the reduction of vibration transmitted to covers, cladding, platforms and structures that are liable to vibrate. The vibration of any such radiating surface shall not exceed the following:

**Table-1.7: Maximum Amplitude for Different Frequencies**

Frequency (Hz)	Amplitude (mm) (Peak-to-peak)
5	0.4
10	0.2
25	0.08
50	0.04
100	0.02
120	0.017

## Nuts, Bolts, Studs and Washers

Nuts, bolts, studs and washers for incorporation in the Plant shall conform to the requirements of International Organization for Standardization (ISO).

All bolts, nuts and screws which are subject to adjustment or removal in the normal course of maintenance shall be made of corrosion-resistant steel or bronze. Stainless steel nuts shall not be used with stainless steel bolts unless the hardness and composition are such as to eliminate any possibility of galling.

## Coupling Guards

All rotating shafts and couplings shall be fitted with rigid guards of wire mesh or plate so designed that accidental contact with the rotating parts is not possible.

## Locks

Locks shall be supplied for all normally closed valves and for electrical cabinets and cubicles. Three keys shall be supplied for each lock and all keys shall be non-interchangeable. All padlocks shall be of brass.

A key cabinet shall be supplied to accommodate the keys. The keys shall have an engraved identification tag and the key hooks in the cabin shall also have engraved labels.

## Lubrication

Grease, oil and hydraulic fluid for all Plant and systems shall be provided by the Contractor for initial filling of all the equipment, plus an additional fifty percent. The types of lubricants and

hydraulic fluids to be used shall be coordinated with the Employer/ Engineer so that the same types may be used throughout the Project. Upon completion of the design, the Contractor shall provide a schedule showing the types, the quantities of oil, hydraulic fluid and grease required for the initial filling of each item of Plant. Any spillage or replacement of hydraulic or lubricating oil during commissioning shall be Contractor's responsibility and the corresponding quantity of the same shall not be considered the part of initial filling plus an additional fifty percent.

Lubricants and greases shall be of types readily available in Pakistan.

During erection, use shall be made of an approved anti-scuffing lubricant, such as molybdenum-di sulphide, on threads of bolts and nuts for items requiring subsequent routine dismantling.

### **Lugs and Lifting Devices**

All equipment over 50 kg weight shall be equipped with lifting lugs or screwed sockets for eye bolts conveniently located for ease of handling. Sufficient eye bolts shall be supplied for the equipment to be handled and these shall be handed over to the Employer/Engineer at the end of the erection period in good working condition. The lugs and eye bolts shall meet the requirements of FEM or other approved recognized international Standards. Lugs and eye bolts shall have a factor of safety of 5 in relation to the load being handled and shall be ultrasonically examined before use.

### **Platforms, Stairways, Ladders and Hand Railing**

#### **xxi. General**

The Contractor shall provide all platforms, galleries, stairways and ladders necessary to give easy and readily access to the various sections of the plant being supplied under this Contract. The Contractor shall provide adequate means of access for all operation, inspection, maintenance and overhaul purposes and shall be of sufficient strength to support workmen, tools and portions of plant which may be placed on them during maintenance and inspection periods.

All galleries, platforms, stairways and ladders shall be of galvanized carbon steel, unless otherwise specified. The Employer/ Engineer may, at his discretion, give permission for other corrosion resistant materials to be used. Galleries, platforms and stairways shall be designed generally for a load of 7.5 KN/m<sup>2</sup> but where loads in excess of this are likely to be imposed during operation or maintenance, the Contractor shall make due allowance for the increased loads in the design. Particular care shall be given to their rigidity. All the necessary supports from the floors, buildings and foundations shall be supplied under this Contract.

Platforms and galleries shall have a minimum width of 850 mm clear passageway and shall be enclosed by hand railing on both sides. In cases where there is a space not exceeding 200 mm on one side of a passageway hand railing need be supplied for one side only but an edging strip shall be provided on the other side. The minimum headroom on platforms and galleries shall be 2100 mm.

Ladders shall only be permissible where stairways are both impractical and access is required for maintenance purposes or for emergency purposes.



All aspects of platforms, stairways, ladders and other access ways shall comply with the requirements of BS 5395 Part 3, unless otherwise stated.

As far as practical the flooring, stair treads and hand rails shall conform to a uniform pattern throughout the whole of the Contract Works.

## **xxii. Flooring**

The flooring of all platforms, galleries and staircase treads shall consist of an approved type of galvanized mild steel open grid flooring except in those cases where chequer plate is specified.

Toe plates extending to a height of not less than 100 mm above the platform or gallery level and of a thickness of not less than 6 mm shall be supplied. Any opening which it is necessary to cut in the open grid flooring or chequer plate shall be finished off with an edging strip similar to that on the floor panels.

The open grid flooring and stair treads shall be by an approved manufacturer and generally in accordance with BS 4592.

The pattern of open grid flooring and chequer plate shall be uniform and laid with the pattern in one direction.

Open grid floor panels shall be not less than 25 mm in depth and shall be fitted neatly between kerbs and clamped with nuts and bolts in such a manner as to permit ready removal or replacement. The design of the clamps shall be to approval and only minimal protrusion above the floor level shall be permitted.

Where chequer plate is supplied it shall be galvanized mild steel to an approved design. No chequer plate shall be less than 10 mm thick over the chequer and all plates shall be secured to the supporting steel by galvanized countersunk screws of not less than 10 mm nominal size.

## **xxiii. Hand Railing and Protective Barriers**

Hand railing and protective barriers shall be provided wherever necessary to protect operation or maintenance personnel from hazards, and shall comply with BS 6180.

Double hand railing shall be provided unless otherwise specified. Each length shall be joined by internal ferrules and all joints shall be neatly finished by the removal of all burrs. The top rail shall be not less than 50 mm diameter and a height of not less than 1100 mm from the gallery or platform level. The intermediate rail shall be not less than 25 mm diameter and at a height of not less than 535 mm from the gallery or platform level. Handrails over stairways shall have the top level at a height of not less than 900 mm and a lower rail at not less than 420 mm above the stairway pitch line.

Tubular or solid forged stanchions shall be provided, spaced at a maximum distance of 1750 mm, and to which hand railing shall be firmly attached.

The stanchions shall be firmly attached to the platform, gallery, stairway or ladder steelwork, but not toe plates, or civil works by bolting, and when erected shall be vertical.

In designing hand railing and the supporting stanchions particular attention shall be paid to the provisions of BS 6180 relating to design loads and to permissible deflections and flexibility.

#### **xxiv. Stairways**

Main stairways shall have a minimum stair tread width of 1100 mm; other stairways shall have a minimum width of 750 mm. wherever possible the angle of slope of stairways shall be standardized. Angles exceeding 42° shall not be used.

No flight of stairs shall have more than 16 risers. Where a stairway requires more than 16 risers, each flight shall have an approximately equal number of risers and shall be separated by a landing. Risings shall be between 190 mm and 210 mm, and goings shall be between 220 mm and 250 mm in width. Minimum headroom shall be 2.1 m.

#### **xxv. Fixed Access Ladders**

Ladders shall comply with BS 4211. The minimum width of ladders shall be 500 mm and shall have an inclination of not less than 70°, or more than 80° to the horizontal.

#### **xxvi. Traps, Drains and Vents**

The Contractor shall provide all traps, drains and vents which are called for in this Specification or which are necessary for plant operation, line or plant filling or warming through.

Drains and vents from different systems, or parts of systems operating at widely differing pressures, shall not be interconnected.

Pipe work associated with drains and vents shall comply with this Specification.

#### **Floor Collars, Wall Boxes and Weather Hoods**

At all points where pipes pass through concrete or other similar floors and walls, suitable floor collars or wall boxes or sleeves shall be provided by the EM Contractor to the Civil works Contractor for incorporation the same in a proper manner.

The EM Contractor shall be responsible to liaise with the Civil Works Contractor so that all required floor boxes or wall boxes are provided as required. The floor collars shall have raised kerbs of suitable height, which shall not be less than 75 mm. The wall boxes shall be flush fitting and of neat design and approved finish.

The Contractor shall provide all necessary fittings for the passage of pipes through external walls and roofs, together with the supply of all necessary components for weather proofing or vermin proofing.

Wherever possible, service pipes running adjacent to each other shall pass through a common box. Where pipes of varying bore pass through a common box, a neat "fill in" cover plate shall be provided between the pipes and the box.

In the case of flanged pipe work, boxes shall be large enough to permit the passage of the flange.

Weather hoods shall be provided at the open ends of all upward facing atmospheric exhaust or vent piping.

# **EMPLOYER'S REQUIREMENTS**

## **CHAPTER-2**

### **TECHNICAL REQUIREMENTS FOR MECHANICAL WORKS**

250 KW SBBU Micro Hydropower Project

## GENERAL

This section specifies the Employer/Engineer's requirements for the design, material selection, manufacturing, assembling, factory testing, packaging, insurance, transportation to the Project site, storage at site, installation & erection, site testing and commissioning, fulfillment of functional guarantees and making good of the defects of Hydro-Mechanical equipment to be supplied for 250 KW Micro Hydel Power station at Shaheed Benazir Bhutto University (SBBU) Sheringal-Upper Dir.

### 2.1 SCOPE OF SUPPLY

Scope of supply under this section demands the EPC Contractor to supply, install and commission the following EM equipment in accordance with the applicable codes and standards and up to the satisfaction of the Employer/Engineer:

- a) Two Nos. (02) horizontal shaft cross flow turbines each with rated output of 143.5 KW.
- b) Two Nos. (02) Main inlet butterfly valves of DN 1000.
- c) Two Nos. (02) horizontal shaft synchronous Generators.
- d) Gear Box with appropriate coupling ratio (n) to synchronize the Generator RPM with turbine.
- e) Two (02) sets of electrical and hydraulic governors.
- f) Auxiliary equipment and all other parts like Turbine base frames, connectors, switches, valves, connecting pipes, joints etc.
- g) Ancillary systems including compressed air, cooling water system, fire fighting, HVAC, emergency lighting and alarm system, lubrication and oil handling, potable water, sewerage, drainage and dewatering systems with all design considerations.
- h) Workshop equipment with necessary tools and spares for at least 5 years trouble free operation and maintenance of the plant.
- i) Radio operated Powerhouse crane (5/1 tonne) and 1 tonne JIB crane for handling of DT stoplogs.
- j) All equipment required for Hydraulic steel structures including Forebay Flushing Gate, Inlet slide gates, Penstocks, Air vent pipes with pressure relief valves, Trashracks, and DT-Stoplogs.

The scope of supply shall also include all parts, accessories, spares etc. which are essential for initial assembly, erection, construction, trial operation, trial run, test run, commissioning, testing and maintenance of the complete unit even though these are not specifically stated or enumerated. The corresponding components of all the turbines and associated equipment and spares shall be of the same material, dimensions and finish and shall be interchangeable.

The turbine manufacturer shall co-ordinate with the generator supplier so that the generator coupled to the turbine is matched in respect of speed, runaway speed, moment of inertia, over load as well as partial load capacities, coupling and other relevant requirements.

The efficiency of the turbine shall be as high as possible and however shall be preferably not less than 80% at rated conditions. The turbines shall be installed in a surface power station and all main & ancillary equipment shall be suitable for operation under the temperature & humid conditions prevailing inside the power station.

Each turbine shall be provided with a common pressure oil system for operation of the needle & deflector operating mechanism, and main inlet valve. The grade of the oil shall be selected considering the climatic conditions of the project site so that even at very low temperature (i.e. up to 0° C), it may flow smoothly without causing any operational problem.

All necessary transducers & digital interfacing equipment shall be included in the scope.

## **2.2 SPECIFIC STANDARDS FOR TURBINES**

Turbines shall meet provisions made in the following standards (latest edition) unless otherwise mentioned

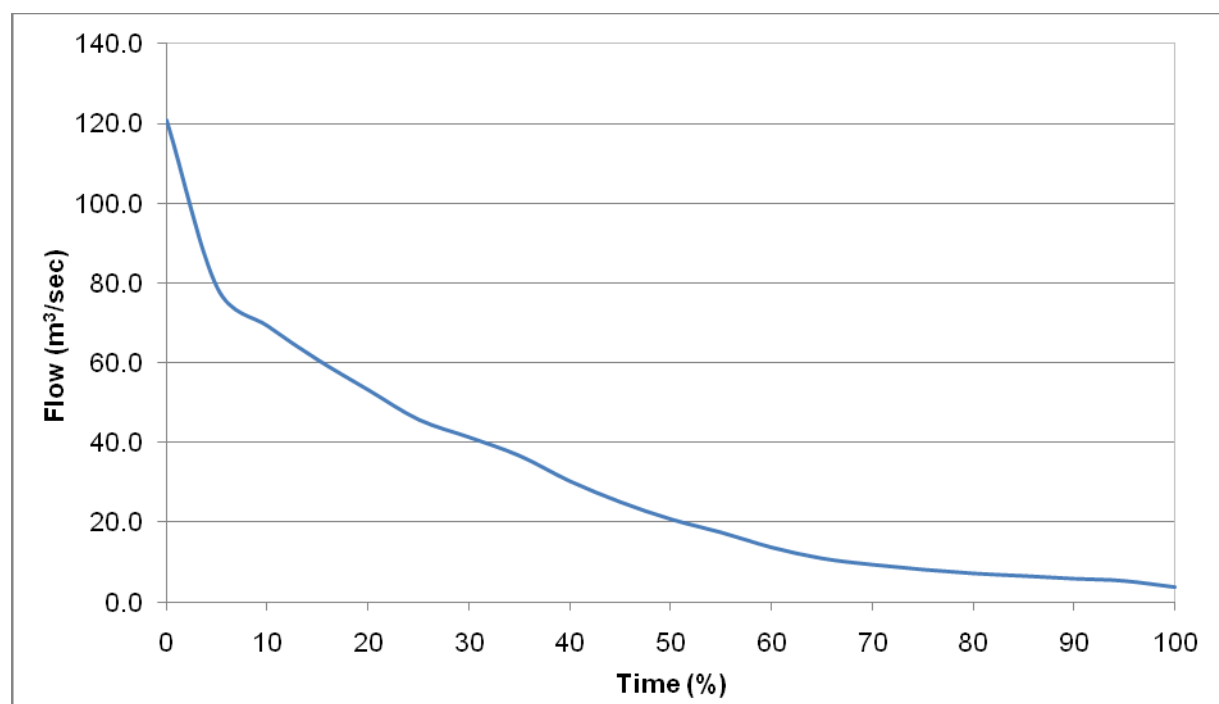
- a) IEC 60041 - Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
- b) IEC 60193 - International code for model acceptance of hydraulic turbines
- c) IEC; 60308 - International Code for Testing of Speed Governing Systems for Hydraulic Turbines
- d) IEC 60545 - Guide for Commissioning, Operation, and Maintenance of Hydraulic Turbines
- e) IEC 60609 - Cavitation, Pitting Evaluation in Hydraulic Turbines, Storage Pumps and Pump-Turbines
- f) IEC 60994 - Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps, and pump turbines)
- g) ISO 7919 (Parts 1-5) – Mechanical Vibration-Evaluation of machine vibration by measurements on rotating shafts

Equipment complying with other internationally accepted standards such IEC, BS, USA, etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case the Bidder shall clearly indicate the standards adopted and furnish a copy in English of the standards adopted along with copies of all official amendments and revisions in force as on date of opening of Bid and shall clearly bring out the salient features for comparison.

## **2.3 MAIN DESIGN PARAMETERS**

### **2.3.1 Plant Rated Discharge**

Selection of the plant rated discharge is based on a number of factors including mean monthly flows, flow duration curve and type of plant with respect to its operation. SBBU hydropower project is a dedicated power station which is being constructed to cope up with the electricity requirements of the University campus. The design discharge has been optimized as 6 m<sup>3</sup>/sec on the basis of Campus energy requirements instead of available energy potential, wherein it is confirmed that the plant rated discharge shall be available at least 90% of the time per annum.



**Figure-2.1: Flow Duration Curve at SBBU Site**

### 2.3.2 Water levels and available Net Head.

The maximum and minimum Forebay levels (HWLs) are 2428.95 and 2428.50 m.a.s.l (almost fixed). Centre line of the Cross Flow turbine is proposed at 2422.75 m.a.s.l which shall be at least 2 meters above normal tail water level.

**Table-2.1: Different water levels & rated net head**

Sr.No	Parameters	SI Units (Metric)	FPS (British)
1	Max. Forebay pond Level (fixed)	2428.95 m.a.s.l	7969.00 ft.asl
2	Max. Tail water Level (TWL)	2418.77 m.a.s.l	7935.60 ft.asl
3	Proposed Turbine center line Elevation	2422.5 m.a.s.l	7948.22 ft.asl
4	Maximum Head Loss In Water Conduction System	0.35 m	1.15 ft
5	Rated Net Head (All Units Operation)	6.10 m	20.01 ft
6	Design discharge for 2 Units m <sup>3</sup> /s	6 m <sup>3</sup> /s	211.72 ft <sup>3</sup> /s
7	Discharge for 1 Unit at 100% Load	3 m <sup>3</sup> /s	105.86 ft <sup>3</sup> /s
8	Permissible pressure rise in Penstocks on tripping of all the machines when operating at maximum load	25 % of Maximum static head	-
9	Maximum Permissible Speed Rise on Load Rejection at Maximum Output	30% of the rated speed	-

### 2.3.3 Selection of Turbines

On the basis of available data of head and water discharges the type and number of turbines are finalized. Selection of an under rated turbine can result in the loss of water and loss of energy potential whereas selection of an over rated turbine can increase the initial cost of the project in addition to the low turbine efficiency when operating at partial discharge. Therefore significance of hydrological data is important.

**Table-2.2: Range of Turbine Types (based on available head)**

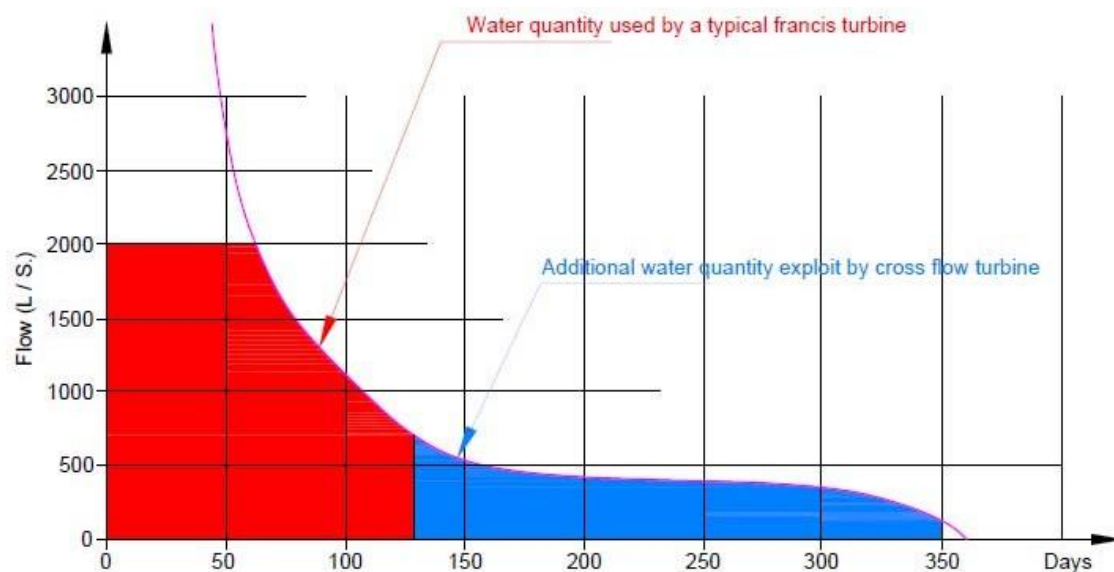
<i>Turbine Type</i>	<i>Head Range in Meters</i>
Kaplan and Propeller	$2 < H < 40$
Cross Flow	$6 < H < 350$
Pelton	$50 < H < 1300$
Michell-Banki	$3 < H < 250$
Turgo	$50 < H < 250$

The above table from different hydraulics' hand books shows a conceptual approach for type of turbine selection on the basis of available heads. It is clear that the Cross flow or Michell-Banki turbines have widest ranges of applicable heads to be adopted and hence are the most suitable type for such small / micro hydro projects being covered under this project.

### 2.3.4 Cross Flow Turbine

Horizontal intake Cross Flow turbines shall be the most suitable choice for this project sites as very low head is available for this project site. Moreover, there is a large variation expected in electricity demands (between 100% and 50%) of the plant capacity due to off-session months in the University campus every year periodically, therefore a wide range of adaptability shall be required in terms of load management.

The basic factor favouring cross flow turbine is "to provide maximum energy during whole period of the year and keep the total blackout time to the minimum" that is the selected turbine must be capable of providing at least some power even during low flow months (winter months usually from November to February). Cross flow turbine fulfils the criteria due to its wider range of operation as suggested by the following figure taken from an actual project of one of the well-known international OEM of cross flow turbines.



**Figure-2.2: Operating Range of Francis Vs Cross Flow Turbine**

The operation of Francis turbine is limited to a minimum of 30% of rated discharge whereas the cross flow turbine doesn't have such limitations, rather it can operate at 17% of the rated discharge or even lesser without a significant drop in the turbine efficiency.

### 2.3.5 Type, Rating and Description

Each turbine shall be of the horizontal shaft Cross Flow type suitable for direct coupling to water wheel generator to give output of 129 KW (installed capacity of one Unit) with suggestive rated speed of 500 rpm at the terminals of synchronous generator at rated net head of 6.10m and unit rated discharge of 3.0 m<sup>3</sup>/s.

The specific speed of the turbine shall be as per the best modern practice & of proven design and shall correspond to rotational speed of 500 rpm (the rotational speed of turbine to be reconfirmed by the EPC Contractor). The speed and setting of the turbine and its design shall be such as to result in the installation of the best generating unit. The direction of rotation shall be anti-clockwise as viewed from the generator end or as decided by the manufacturer.

The turbine shall be such that it takes care of water hammer effect in case of sudden load rejection of all the machines simultaneously.

The contractor will carry out the transient analysis and submit his report for Consultant/Employer/Engineer's approval in order to establish the turbine closing time, pressure release mechanism and other safety factors required for fail-safe operation for all possible operating conditions including emergency shutdown.

The weights and sizes of the packages/sub-assemblies shall be within the permissible transport limitations fixed on the basis of the access roads surveys conducted by the Contractor.

The best efficiency of the turbine shall be obtained by operating at rated head conditions and delivering optimum output. The maximum output, discharge & efficiency at the minimum permissible and maximum net head as mentioned hereinabove shall be indicated in the bid.



The turbine shall operate safely and satisfactorily continuously within the maximum and minimum operating heads. The operating characteristics of turbine as a function of head vs. output shall be furnished with the bid.

### 2.3.6 Selected Number of Units and Installed Capacity

Based on the analysis of annual energy demands by the University campus, two (02) Units of equal rated discharge of 3.0 m<sup>3</sup>/s have been selected such that both Units shall be available for operation at full capacity for 90% of the time throughout the year and one Unit at full load during the lowest flow periods for the months of January, Feb, Oct, Nov and Dec.

However, if the electricity demands drop during off-session times, the cross flow turbines and synchronous generators shall be capable of dealing with reduced demands by operating at controlled flow of up to 20% of the rated discharge.

**Table-2.3: Number of units and plant capacity**

Parameters		Values	Units
Turb CL setting above max TWL (CL)		2	m
Gross head	H <sub>g</sub>	8.23	m
Head loss for each Penstock	H <sub>L</sub>	0.51	m
Net rated Head	H <sub>net</sub>	7.72	m
Total Design Discharge (2-Units)	Q <sub>t</sub>	6.00	m <sup>3</sup> /s
Design Discharge for 1 Unit	Q	3.00	m <sup>3</sup> /s
Turbine Efficiency	η <sub>t</sub>	80%	-
Generator Efficiency	η <sub>g</sub>	90%	-
Acceleration due to gravity	g	9.81	m <sup>2</sup> /s
Rated Capacity of each Unit	P <sub>r</sub>	181.8	KW
Installed Capacity of each Unit	P	163.6	KW
Plant Installed Capacity (2-Units)	P	327.2	KW
Internal losses/auxiliaries consumption	(up to 2%)	7.2	KW
Net Plant Capacity (2-Units)	P <sub>net</sub>	320	KW

## 2.4 TECHNICAL SPECIFICATIONS FOR TURBINES AND ASSOCIATED EQUIPMENT

### 2.4.1 Output and Efficiency Guarantees

The rated output of the turbine at rated head shall be stated and guaranteed by the EPC Contractors. The efficiencies of the turbine and generating unit shall be as high as possible. The efficiency of the turbine at rated head of 7.72m & rated discharge of 3m<sup>3</sup>/s for 100%, 90%, 80%, 70, 60%, and 50% rated output of Turbine - Generator unit shall be guaranteed and indicated. In addition, the maximum outputs of the turbine at full opening of the guide vanes at rated / net head of 7.72 m shall also be guaranteed in the bid. The turbine shall also be suitable, safe and give efficient performance at part loads lesser than 50% of the rated output.

Bidder shall furnish details of test methods, agency which will conduct the test, provisions to be made for field testing, calibration of instruments for purposes of test and all other relevant details in the offer. Contractor shall be under obligation to accept these tests for purposes of liquidated damages. The Employer/Engineer reserves the right to appoint the Contractor or any independent agency or agency recommended by the consultants for conducting these tests.

### 2.4.2 Weighted Average Efficiency

The Weighted Average Efficiency of the prototype turbine shall be determined from the field efficiency test values of efficiency at the rated head of 6.10 m in accordance with the following formula for the purpose of penalty, rejection limits and bid evaluation. The field tests on the turbine shall be carried out by the Contractor as specified in IEC. The field test on the Generator will also be carried out as per appropriate IEC.

$$\eta_{tw} = \frac{W_1 \cdot \eta_1 + W_2 \cdot \eta_2 + \dots + W_n \cdot \eta_n}{W_1 + W_2 + \dots + W_n}$$

The efficiency data for the following turbine output data are included in the formula together with the weighting factors as follows:

<b>P<sub>t</sub>(MW)</b>	<b>100%</b>	<b>90%</b>	<b>80%</b>	<b>70%</b>	<b>60%</b>	<b>50%</b>	Calculation for weighted average efficiency
<b>W</b>	<b>40</b>	<b>20</b>	<b>15</b>	<b>10</b>	<b>10</b>	<b>5</b>	

Weighted average efficiency of the turbine as determined from the above formula shall be based on minimum turbine rated efficiency of 80% at rated conditions guaranteed by the turbine manufacturer. These figures shall be applicable for the purpose of penalties, rejection limits and bid evaluation. In addition the outputs as per discharge conditions used for calculation of generation shall also be guaranteed. The output of the turbine at various openings of guide vanes from full opening to lowest operational opening size shall be stated in the bid & guaranteed technical particulars. Guarantee is fulfilled only if it is in accordance to the IEC code 60041 or relevant IEC codes at given discharges.

## **2.5 PENALTIES**

### **2.5.1 Penalty for Shortfall in Weighted Average Efficiency and Output**

For each percentage point in performance or weighted average efficiency (as determined on the basis described in Sub clause 2.4 and approved by the Employer/Engineer) below the rated value specified in the Specifications but above the minimum acceptable levels also specified there, an adjustment of 1 Million Pak Rupees will be adjusted to the bid price.

### **2.5.2 Rejection Limit**

The Employer/Engineer reserves the right to reject the turbine-generator unit if the test values of either weighted Average Efficiency as determined by Clause 2.4.2 or the rated output is less than the corresponding guaranteed values by 2% (two percent) or more including tolerances in computation of efficiency.

### **2.5.3 Rectification to Meet Guarantees**

- i. In case the specified tests prove unsuccessful in meeting the guaranteed values, the Contractor will be given 2 months or mutually agreed reasonable time period to improve or modify the design of the turbine or to carry out rectifications etc, as may be required so that the guarantees are met. However, no delay in the original project completion schedule shall be allowed if the model test results do not meet the guarantees and rectifications are made by the contractor thereafter within a period of 2 months or mutually agreed period as stated above without extra cost to the Employer/Engineer.
- ii. If such attempts to improve or modify or rectify fail, taking remedial action by the Employer/Engineer at Contractor's risk & expenses without prejudice to other terms and conditions of contract or imposing of penalty or rejection of the equipment as the case may be, shall be applied.

### **2.5.4 Speed Rise & Speed Regulation**

The moment of inertia of the unit ( $\geq 3.5 \text{ tm}^2$  – to be reconfirmed & settled by the Contractor in accordance with his own 'transient analysis' and max. hydraulic thrust calculations), normal closing time and emergency shutdown time shall be so adjusted such that the maximum momentary speed rise of the unit shall be kept safely below the runaway speed.

However the momentary speed rise shall not exceed 30% of the rated speed and pressure rise in the penstock shall not exceed 25% of the maximum static head under any conditions of operation.

The turbine manufacturer shall co-ordinate with the generator manufacturer for achieving the required flywheel effect to maintain the speed and pressure rise within specified limits.

### **2.5.5 Runaway Speed**

The maximum runaway speed of the unit under any combination of head and load conditions shall be stated in the bid. The runaway speed may be as low as possible. Turbine and Generator parts shall be designed and coordinated to withstand maximum runaway speed without any damage to its parts for 15 minutes duration continuously for every occurrence with cooling water supply on. The calculated first critical speed shall be at least 25% higher than the maximum runaway speed.

### 2.5.6 Cavitation Guarantees

The Bidder shall guarantee the runner and other hydraulic passage against excessive pitting caused by cavitation for 24 months from the date of commissioning or 8000 hours of actual operation whichever is earlier.

Excessive pitting shall be defined as the removal of metal from the runner and other hydraulic passages of a weight of:

$$W = 0.025 D^2 \text{ per 1000 hours of operation}$$

Where D = Pitch circle diameter of the runner in meter and W = Weight in kg.

If the 24 months of guarantee period expires before completion of 8,000 hours of operation, the guarantee shall apply to the actual hours of operation proportionately.

In case of cavitation pitting exceeding the guarantee, the Contractor shall at his cost take corrective measures such as reshaping or resurfacing, grinding, polishing, building up by welding or by any other means and rectify/replace the part thus affected and carry out such modifications in design and such improvements in the manufacture and finish as may be required to minimize cavitation pitting within permissible limit. The turbine after carrying out the necessary modification shall be subject to cavitation guarantee as for the original equipment. In determining whether or not excessive pitting has occurred, metal removed by erosion, corrosion, or by the presence of injurious elements in water etc., shall be measured and taken into account. In addition, the Contractor shall also be liable to bear the revenue cost lost due to loss of generation.

### 2.5.7 Noise Level

Maximum noise level at any of the operating conditions shall not exceed **90 db (A)** at any place 1.0m away from any operating part of equipment detected in the machine hall. Any vibration caused by the machine should not be in resonance with any part of the equipment delivered.

### 2.5.8 Stresses, Factor of Safety and Guarantee

All parts of turbine shall be designed and constructed to safely withstand the maximum stresses during normal running, speed rise, runaway speed, short circuit conditions, out of phase synchronizing and brake or grid fail application. The maximum unit stresses in the rotating parts under such abnormal conditions of operation shall not exceed 2/3 (two-thirds) of yield point stress of the material. For other parts, the factor of safety based on yield point stress shall not be less than 3 (three) at normal conditions.

For over-load and short circuit conditions, a factor of safety of 1.5 on yield point stress shall be permitted. All parts shall be guaranteed to withstand a minimum time of 1,50,000 hours of miscellaneous operation equivalent to 1,00,000 operational hours at full load.

## 2.6 SELECTION OF TURBINE MANUFACTURER

The selected turbine supplier / manufacturer (Local or Foreigner) shall be the one who has the following capacities/capabilities:

1. In case of Local supplier, the manufacturer shall be ISO certified to demonstrate that the Quality Management System is being followed by the Factory. International supplier must be accredited by world renowned certifying bodies to establish the credibility for quality assurance and quality control.
2. The supplier must have capability to follow the international codes and standards as referred above.
3. In case of International supplier the supplier must be an OEM (Original Equipment Manufacturer) with his own patent design in the international market.
4. The manufacturer must have own manufacturing and testing facilities where turbines and associated equipment are manufactured and inspected/ tested for proven performance.
5. The manufacturer must have capabilities to provide the design calculations, system principal diagrams, shop drawings, installation manuals and O&M manuals as per agreed documentation system.
6. The manufacturer must ensure to provide the support for after sale services and parts for at least 5 years after one year of Defect Liability Period (DLP) is over.

### **2.6.1 Inspection and testing of Mechanical equipment**

A comprehensive inspection and testing plan shall be prepared by the Contractor and submitted to the Employer/ Engineer for review and approval in order to ensure the quality of the equipment at three stages, that is during manufacturing/fabrication, finished product (before shipment from the workshop or before installation at site) and at the time of commissioning.

Project manager will decide the extent of testing and inspection of the mechanical components both at manufacturer's facilities as well as on project site. The Contractor will be responsible for all costs incurring for these Tests as detailed under *Chapter 1 – General Requirements for Mechanical Works*.

Equipment to be inspected may include but not limited to the Turbine runners, Turbine shafts and connecting flanges, housings, guide vanes, deflectors, pressure relief valves, Main Inlet butterfly valves, Penstocks, bearing assemblies and other auxiliary equipment.

## **2.7 MAJOR COMPONENTS OF CROSS FLOW TURBINE**

Major parts of the cross-flow turbine include embedded parts, base frame, rotor/runner, casing, straight reducer, guide vane, servomotor, counter weights, lever arms, self-aligned roller bearings, connecting shaft, corner casing, suction valve and draft tube etc.

### **2.7.1 Runner Casing**

The runner casing and corner casing will be fully steel welded that will allow an easy dismantling of the runner and shaft radially without removing the guide vanes and servomotors. The corner casing will be removed for primary inspection of the runner by simple dismantling tools and without special skills.

Maximum water hammer and pressure rise in the casing during load rejections and emergency shutdown shall be considered for detail design and testing shall be performed in accordance with the Rules of Construction of Unfired Pressure Vessels. Section VIII of the ASME Boiler and Pressure Vessel Code.

### **2.7.2 Turbine Shaft**

The shaft will be dimensioned to be able to operate at any speed up to maximum runaway speed without any harmful vibrations or distortions. The solid type shaft will be of forged open hearth or electric furnace steel, properly heat-treated, accurately machined and smoothly finished throughout, with integrally forged both flanges for bolting to the generator shaft and the runner respectively.

### **2.7.3 Guide Vanes**

A set of two balanced profile subdivided guide vanes complete with lever arm and counter weight assembly will be provided to control the admission of feed water smoothly without causing any anomalous vibrations. Both guide vanes shall be capable of synchronous as well as independent operation to maintain the runner speed during part load operation and fluctuating water streams. Independent adjustment of both guide vanes shall be possible by separate lever arms through manual or automatic controls.

### **2.7.4 Runner**

Drum shaped runner with cold rolled fine profiled blades and smoothly welded end discs shall be provided. The runner's core shall be cast of 13% chrome 4% nickel and fully shop assembled with its shaft.

All surfaces of the runner exposed to the flow of water will be carefully machined and finished smooth to templates. The average surface finish shall be 4 microns or finer in areas subject to possible cavitation. All other areas shall be finished to 10 microns or less. There will be no hollows, depressions waviness, projection and / or other surface imperfections that might lead to local disturbances, erosion, vibrations or cavitation.

The runner shall be designed to withstand the forces encountered during all normal and abnormal conditions up to and including the guaranteed runaway speed.

A large quantity of sediments passing through the turbine could cause significant abrasion on runner. Protective measures must be taken to extend the life of the runner. A number of coatings have been developed which increase the wear resistance of turbine parts that are subject to erosion damage. These coatings include hard Tungsten carbide coatings applied by special equipment under factory conditions and soft coatings like special polymer that can be applied by brush.

### **2.7.5 Governor**

The Digital Governor proposed shall be the most current model in a substantial line of governors designed and manufactured by the digital governor suppliers and shall have previously been installed and used successfully on a number of Cross flow turbine hydro schemes.

### **2.7.6 Bearings**

SKF and NTN self-lubricating type self-aligned roller bearings shall be used in these turbines; bearings shall be fixed at bearing brackets mounted on the side flange which shall be supported by side plates (or main body) of the turbine.

The EPC Contractor shall be responsible for submitting mill certificates for all the materials specified in his design in accordance with material standards given in this tender document.

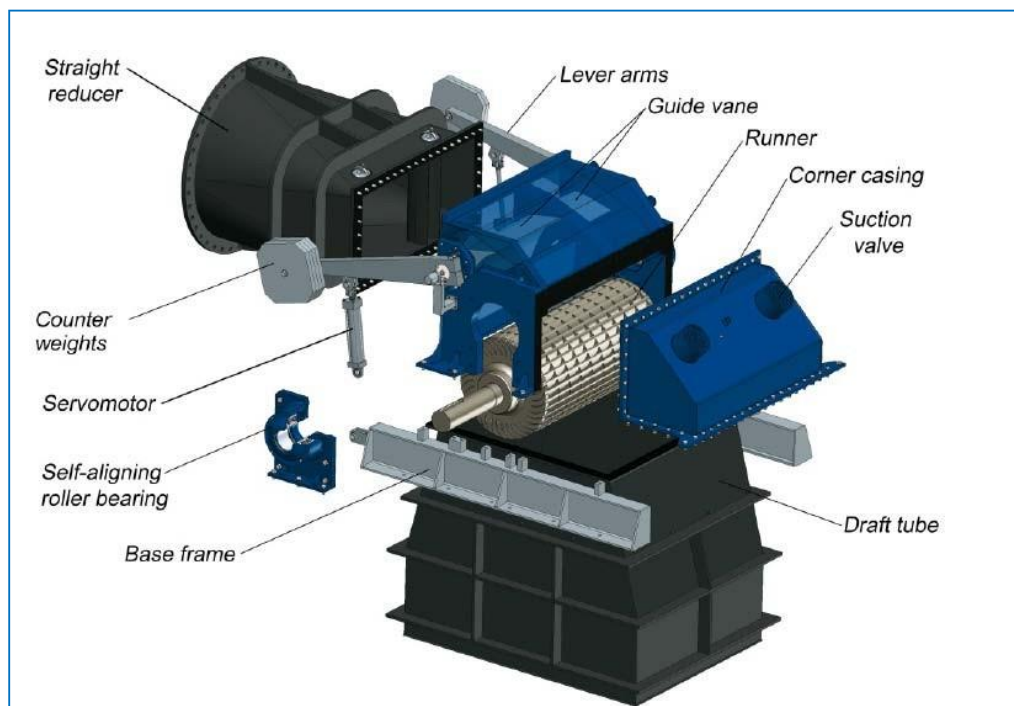


Figure-2.3 : 3D overview of a Typical Cross Flow turbine with major items

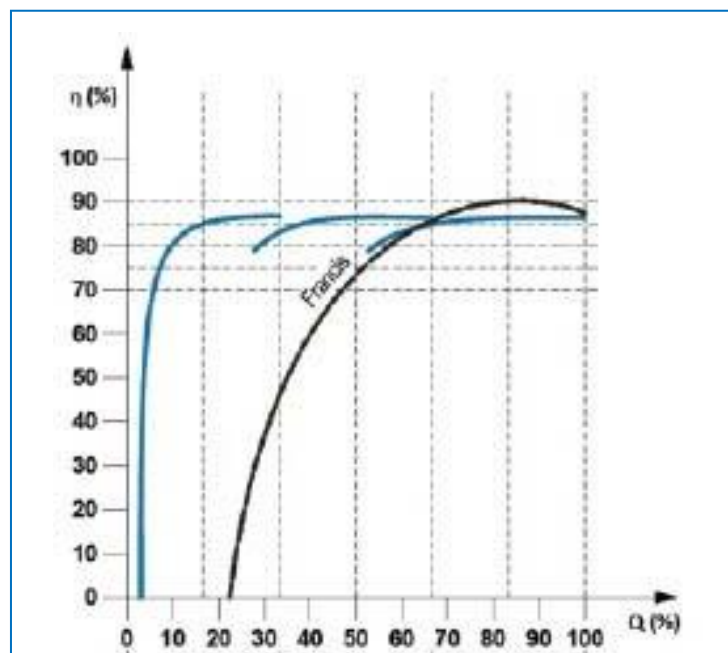


Figure-2.4: A typical Cross Flow Efficiency Curve Vs. Francis Efficiency Curve

### 2.7.7 Main Inlet Valve (Butterfly Type)

Two (02) DN1000 main Inlet Butterfly type valves will be installed on both penstocks at each turbine inlet not only to open or close the water supply to the turbine but also to regulate the water flow as per turbine requirements for partial load operation during off session periods of

the year. Design head of these hydraulically operated control valve shall be 20m and it will be capable to control the partial flow conditions with accuracy of 97.5% that is the permissible error should not increase beyond +/- 2.50%. The valve body shall be manufactured from ductile Iron which incorporates a positively retained resilient disc seal (stainless steel or Bronze) having the following features.

- Self-lubricating shaft bearings reduce friction and operating torque.
- Lockable disc options available.
- Anti-Flutter disc to shaft connections.
- Lifting points as standard.
- Segmented seal retainer maintenance facilitated.

### **2.7.8 Coupling on Generator Shaft**

Coupling on the shaft dampens the amplitude of vibrations, isolating one shaft from the effects of the other. The first purpose of coupling is to transmit power that is torque from one shaft to another, thereby causing both to rotate in unison, at the same RPM. The second purpose is to compensate for small amounts of misalignment and random movement between the two shafts.

Flexible couplings are made of elastic materials, like rubber, or have various other configurations. During rotation, flexible couplings can accommodate misalignment and motion.

### **2.7.9 Powerhouse Crane**

An overhead electric operated bridge crane shall be provided to assemble and disassemble the heavy turbo generator components during the installation process and also during the repair and maintenance of the powerhouse items. The lifting capacity of the overhead bridge crane is based on the maximum possible weight of a single piece of equipment to be lifted / moved by the Crane. Based on the previous experience, a 5/1 ton double girder two hoist trolley, electric operated overhead bridge crane has been recommended for precision handling of items such as generator rotor, turbine runner and shaft assemblies. However, the lifting capacity shall be finalized on the basis of machine weights data provided by the manufacturers. The low speed main hook will handle heavier loads and higher speed auxiliary hook will be used for lighter loads. The lifting height of the hoists is estimated as 5m.

The main crane hook shall be capable of lifting the highest component off the transport – vehicle and both the main and auxiliary hooks shall be capable of reaching as far down as required to serve the inlet valve area. Crane hooks approach distances shall be fixed either as per CMAA or FEM standards. Access to the crane shall be provided through ladder located near the entrance door. The rail section and size shall be finalized corresponding to the wheel load as per FEM or CMAA standards.

### **2.7.10 Wall Mounted Rotatable Arm JIB Crane**

As shown on the powerhouse drawings, a wall mounted rotatable arm JIB crane of 2 tonne capacity shall be provided at outside of the powerhouse downstream wall to handle the draft



tube Stoplogs as per requirements during repair and maintenance of the turbines and/or for flood protection. The crane will be installed in the middle of both draft tubes such that the horizontal arm of the crane will be capable to rotate at 180° to handle the draft tube Stoplogs of both turbines.



*Fig: Specimen of rotatable arm JIB crane*

## **2.8 MECHANICAL AUXILIARIES**

Since Turbine rated capacities of SBBU Microhydro power project are very low (181.8 KW each) therefore the corresponding capacities of the mechanical auxiliaries need to be precisely determined on the basis of manufacturer's own design to keep the cost at the minimum.

Following auxiliary systems have been foreseen for smooth and trouble free operation of the powerhouse. However these systems are indicative for the Turbine manufacturer. The contractor / manufacturer shall submit his customized detailed design and include the ancillaries as per requirement of the cross flow turbine Unit.

- Compressed Air system - Low pressure
- Station Drainage & Dewatering System
- Potable / Service water and Sewage system
- Fire extinguishing system
- Heating, Ventilation and Air conditioning system
- Greasing, oil handling and lubrication system.
- Emergency lighting and alarm system

## **2.9 WORKSHOP EQUIPMENT**

The mechanical workshop, inside the power house, will be supplied with equipment sufficient for the following tasks:

- Dismantling and erection of all turbine parts.
- Repairing or renewal of components with minor defects, not needing specialized skill or experience.
- General workshop tools

Table-2.4: Workshop tools

	TOOLS	Unit	QTY
1	Hydraulic jack, plates for mounting and dismantling of flywheel	Set	11
2	Hydraulic puller for mounting Spanners of size 100 mm to 40 mm	Set	1
3	Socket sets	Sets	2
4	Torque wrenches (of different ranges)	No	1
5	Pliers set	Sets	2
6	Allen key set	Sets	2
7	Filler gauge	Set	1
8	Adjustable wrench 6 inch	No	1
9	Adjustable wrench 10 inch	Nos	2
10	Dial indicator	Set	1
11	Iron Hammers (1 kg, 3 kg and 5 kg)	Nos	2
12	Plastic Hammers (small and large)	Nos	2
13	Chisel	Nos	2
14	Electric drill machine with drill bit set	No	1
15	Electric grinder	Set	1
16	Spirit level	No	1
17	Tri square (large size)	No	1
18	Steel ruler (1-meter length)	No	1
19	Measuring steel tap (3m, 5m)	No	1
20	Screw driver flat /Philips	Nos	2
21	File set	Set	1
22	Grease gun	Set	1
23	Scraper (flat and angular)	No	1
24	Pipe wrench (small, medium and large)	Nos	2
25	Small socket set for diode	Nos	3
26	Knife and scissor set	Set	1
27	Special tools for governor	Set	1
28	Multi meter matching with generator	Set	1
29	Clamp on meter matching with generator	No	1
30	Bench vice	No	1
31	Chain Pulley Block and winching arrangement (1tonn)	No	1
32	Lifting belts 1,3,8 & 10-ton capacity	Set	1
33	Mandatory Jigs & Fixtures	No	1 each type

34	Upper Contour Welding Jig	Set	1
35	Lower Contour Welding Jig	Set	1
36	Runner Blade Machining Jig	Set	1
37	Housing Welding Jig	Set	1
38	Hand Regulator Support Welding Jig	Set	1

## 2.10 HYDRAULIC STEEL STRUCTURE EQUIPMENT

Based on the hydraulic design of the project site different Hydraulic Steel Structures (HSS) components shall be required to operate and regulate the power generation at the SBBU powerhouse.

This section covers the basic design data of the HSS components including the following major items:

- Two (02) Nos. manually operated slide gates at intake.
- Two (02) sets of Intake Trashracks
- One set of fixed wheel flushing gate at intake flushing channel.
- One set of vertical lift type fine trashracks at fore-bay intake
- One set of manually operated slide gates at fore-bay intake to isolate the fore-bay
- Flushing gate at fore-bay flushing channel
- Manually operated slide gates at penstock inlet
- Trashrack at Penstock slide gates.
- Penstock Pipes and accessories
- Air vent pipes for both penstocks with pressure relief valves
- Draft tube Stoplogs

The equipment included in the following part of the document shall be as per general description given here under and as shown in the relevant drawings, suitable for operating functions as defined. It shall be simple in design and give long trouble free service with minimum maintenance.

Following dimensions/sizes of the gate equipment and also shown in the drawings are tentative. Any item which is essential for the efficient performance of the equipment but not specifically mentioned in these specifications shall be considered as part of the Scope of supply of the contractor.

### 2.10.1 Codes & Standards

The fabrication and metal works under this section shall be referred to the applicable clauses of the following general groups of international codes & standards.

The supplier shall refer to standards within these general groups in defining the characteristics of the equipment and HSS components under his scope of supply.

**Table-2.5: Codes and standards for HSS equipment**

No.	Description of items	Code
1	Dimensions and units	ISO
2	Ferrous and non-ferrous material for fabrication	ASTM
3	Welding procedures and welder qualifications for pressure vessels	ASME
4	Structural welding	AWS
5	Non-destructive testing	ASME & ASTM
6	Materials testing	ASTM
7	Pipework, supports	ANSI
8	Fastenings	ISO
9	Painting	SSPC
10	Hoisting and handling equipment	FEM

**2.10.2 Manually Operated Slide Gates at Intake**

Two (02) Nos. manually operated slide gates shall be provided at intake, upstream side of the trash rack to isolate the power channel as and when required for inspection, repair and refurbishment as shown on the intake drawings. The gates are to be operated under unbalanced head condition with the help of individual manually operated stem rod hoists of adequate capacity. The gates and embedded parts shall be designed to withstand an unbalanced Hydro static head of 6.0m or more corresponding to maximum surge level.

The Contractor will submit its design calculations for embedded parts, skin plate thickness and number of girders/ members considering the maximum flood level of 7996.61 ft. with a total head of 20 ft.

**Table-2.6: Data of manually operated slide gate**

i)	Type of Gate	:	Slide gate with upstream skin plate and upstream seals, regulating type i.e. may be kept at partial opening.
ii)	No. of Bay	:	Two (2 )

iii)	No. of gates	:	Two (2 )
iv)	No. of embedded parts	:	1 Set
iv)	Clear width of each opening	:	4 ft (1.22m)
v)	Clear height of opening	:	5 ft (1.52m)
vi)	Sill level	:	7979.50 ft.asl (2432.18 masl)
vii)	Max. Flood Level	:	7996.61 ft.asl (2437.39 masl)
vii)	Level at full open position	:	7982.50 ft.asl (2433.09 masl)
viii)	Design head	:	20 ft (6m)
ix)	Type of side & top seals	:	Music note Teflon clad rubber.
x)	Type of bottom seal	:	Rubber, wedge
xi)	Position of skin plate & side seal	:	Up Stream
(xii)	Lowering/raising speed of hoist	:	11.8in/min (30 cm/min)
xiii)	Operation	:	Lowering / raising under unbalanced head conditions by stem rod hoist.
xiv)	Permissible Stresses	:	Wet & Accessible, DIN or US Corps manual

### 2.10.3 Intake Trashrack

Two (02) sets of trashracks shall be provided at the intake on downstream side of the slide gates to stop the trash and organic debris from entering the power channel. These trash racks shall be placed such that these can be easily removed for cleaning with the help of chain pulley and winching arrangement as shown on the drawings.

**Table-2.7: Data of Intake trash rack**

<b>Intake Trash rack design data</b>	
<b>Clear width of opening</b>	<b>4 ft (1.22m)</b>
<b>Clear height of opening</b>	<b>5 ft (1.52m)</b>
<b>No. of openings</b>	<b>2</b>
<b>Sill level</b>	<b>7979.50 ft.asl (2432.18 masl)</b>
<b>Upstream Level</b>	<b>7982.47 ft.asl (2433.08 masl)</b>
<b>Top of trash rack</b>	<b>7988.29 ft.asl (2434.86 masl)</b>
<b>Clear spacing between trash bars</b>	<b>1.6 in (40mm)</b>
<b>Thickness of Trash Bars</b>	<b>0.47 in (12mm)</b>
<b>Differential head for design</b>	<b>5 ft (1.52m)</b>
<b>No. of sets of trash racks required</b>	<b>2</b>
<b>Operation</b>	<b>Lowering/raising by tripod/chain-pulley block</b>
<b>Second stage concrete in block-outs</b>	<b>M30 Min.</b>
<b>Design Standards</b>	<b>DIN or US Corps manual</b>

#### 2.10.4 Flushing gate at Intake Flushing Channel

One slide type flushing gate has been proposed for sediment flushing at intake flushing channel as shown on the drawing. The skin-plate assembly will be of welded construction with the skin-plate reinforced by horizontal beams. The horizontal beams will be supported by vertical and horizontal members.

The sill seals will be mounted on the downstream face of the skin plate, while the side seals will be mounted along the gate's sides.

Flushing gate will be fitted with L' type rubber side seals with fluorocarbon cladding and compression or wedge type bottom seals. There will be no top seal on the flushing gate.

The preliminary design data for the intake gate is given hereunder.

**Table-2.8: Data of Intake flushing gate:**

<i>Slide gate</i>		
Type of gate	Shoe and guide slide gate	
No. of gates	1	
No. of embedded parts	1 set	
Maximum flood level	7996.61 ft.asl	(2437.39 masl)
Minimum operating level	7983.80 ft.asl	(2433.49 masl)
Elevation of the gate sill	7977.47 ft.asl	(2431.56 masl)
Width of gate	3 ft	(0.914 m)
Height of gate	3 ft	(0.914 m)
Elevation of top of gate in closed position	7980.47 ft asl	(2432.47 masl)
Type of hoisting	Manually operated –Mechanical stem rod system	
Interlocking device	1 set	
Normal rate of gate opening	0.3 ft per minute	(90 mm/min)
Normal rate of gate closing	1.0 ft /min	(304.8 mm/min)

### 2.10.5 Vertical Lift type Fine Trash rack

One vertical lift type fine trash rack shall be provided at inlet of the fore-bay to exclude any fine trash or floating debris from the fore-bay and ultimately to avoid the penstock from passing this debris to the turbine which can otherwise damage the turbine runners. The trash rack shall be placed such as to facilitate the easy removal of the trashrack for cleaning with the help of chain pulley and winching arrangement as shown on the drawings.

**Table-2.9: Data of Intake trash rack:**

<b>Fine Trash rack design data</b>	
<b>Clear width of opening</b>	<b>7 ft (2.133m)</b>
<b>Clear height of opening</b>	<b>5.5 ft (1.67m)</b>
<b>No. of openings</b>	<b>1</b>
<b>Sill level</b>	<b>7964.00 ft.asl (2427.45 masl)</b>
<b>Upstream Level</b>	<b>7969.00 ft.asl (2428.98 masl)</b>

<b>Top of trash rack</b>	<b>7969.50 ft.asl (2429.13 masl)</b>
<b>Clear spacing between trash bars</b>	<b>0.78 in (20mm)</b>
<b>Thickness of Trash Bars</b>	<b>0.39 in (10mm)</b>
<b>Differential head for design</b>	<b>14 ft (4.26m)</b>
<b>No. of sets of trash racks required</b>	<b>1</b>
<b>Operation</b>	<b>Lowering/raising by tripod/chain-pulley block</b>
<b>Second stage concrete in block-outs</b>	<b>M30 Min.</b>
<b>Design Standards</b>	<b>DIN or US Corps manual</b>

### 2.10.6 Manually Operated Slide Gate at Fore-bay Inlet

One set of manually operated slide gate shall be provided at fore-bay inlet, downstream side of the trash rack to isolate the fore-bay channel as and when required for inspection, repair and refurbishment as shown on the intake drawings. The gate is to be operated under un-balanced head condition with the help of individual manually operated stem rod hoists of adequate capacity. The gate and embedded parts shall be designed to withstand an un-balanced Hydro static head of 6.0m or more corresponding to maximum surge level.

The Contractor will submit its design calculations for embedded parts, skin plate thickness and number of girders/ members considering the maximum head of 20 ft.

**Table-2.10: Data of manually operated slide gate:**

<b>i)</b>	<b>Type of Gate</b>	<b>Slide gate with upstream skin plate and upstream seals, regulating type i.e. may be kept at partial opening.</b>
<b>ii)</b>	<b>No. of Bay</b>	<b>One (01)</b>
<b>iii)</b>	<b>No. of gates</b>	<b>One (01)</b>
<b>iv)</b>	<b>No. of embedded parts</b>	<b>1 Set</b>
<b>iv)</b>	<b>Clear width of each opening</b>	<b>7 ft (2.13m)</b>
<b>v)</b>	<b>Clear height of opening</b>	<b>5.5 ft (1.67m)</b>



vi)	Sill level	7964.00 ft.asl	(2427.45 masl)
vii)	Max. Flood Level	7996.61 ft.asl	(2437.39 masl)
vii)	Level at full open position	7972.00 ft.asl	(2429.89 masl)
viii)	Design head	20 ft	(6.1m)
ix)	Type of side & top seals	Music note Teflon clad rubber.	
x)	Type of bottom seal	Rubber, wedge	
xi)	Position of skin plate & side seal	Up Stream	
(xii)	Lowering/raising speed of hoist	11.8 in/min	(30 cm/min)
xiii)	Operation	Lowering / raising under unbalanced head conditions by stem rod hoist.	
xiv)	Permissible Stresses	Wet & Accessible, DIN or US Corps manual	

### 2.10.7 Trashrack at Penstock Slide Gates

An inclined trash rack shall be placed inside the fore-bay tank above inlet of the Penstocks as shown on the drawings. This will be a cores trash rack placed on concrete pedestals such that it can be lifted with the help of chain pulley and winching arrangement as shown on the drawings. This trash rack will not be removed until the Turbine is shut down and the penstocks slide gates are fully closed.

**Table-2.11: Data of Intake trash rack**

<b>Penstock Trashrack design data</b>	
<b>Clear width of opening</b>	<b>18 ft (5.48 m)</b>
<b>Clear height of opening</b>	<b>19 ft (5.79m)</b>
<b>No. of openings</b>	<b>1</b>
<b>Sill level</b>	<b>7957.50 ft.asl (2425.47 masl)</b>

<b>Upstream Level</b>	<b>7969.25 ft.asl (2429.05 masl)</b>
<b>Top of trash rack</b>	<b>7972.00 ft.asl (2429.89 masl)</b>
<b>Clear spacing between trash bars</b>	<b>1.57 in. (40 mm)</b>
<b>Thickness of Trash Bars</b>	<b>0.39 in. (10mm)</b>
<b>Differential head for design</b>	<b>20 ft (6.1m)</b>
<b>No. of sets of trash racks required</b>	<b>1</b>
<b>Operation</b>	<b>Lowering/raising by tripod/chain-pulley block</b>
<b>Second stage concrete in block-outs</b>	<b>M30 Min.</b>
<b>Design Standards</b>	<b>DIN or US Corps manual</b>

### 2.10.8 Flushing Gate at Fore-bay Flushing Channel

One set of slide type flushing gate has been proposed for sediment flushing at forebay flushing channel as shown on the drawing. The skin-plate assembly will be of welded construction with the skin-plate reinforced by horizontal beams. The horizontal beams will be supported by vertical and horizontal members.

The sill seals will be mounted on the downstream face of the skin plate, while the side seals will be mounted along the gate's sides.

Flushing gate will be fitted with L' type rubber side seals with fluorocarbon cladding and compression or wedge type bottom seals. There will be no top seal on the flushing gate.

The preliminary design data for the forebay flushing gate is given hereunder.

**Table-2.12: Data of Forebay flushing gate**

<i>Slide gate</i>	
Type of gate	Shoe and guide type slide gate
No. of gates	1
No. of embedded parts	1 set
Maximum flood level	7996.61 ft.asl (2437.39 masl)

Minimum operating level	7969.00 ft.asl	(2428.98 masl)
Elevation of gate sill	7952.50 ft.asl	(2423.95 masl)
Width of gate	5 ft	(1.52m)
Height of gate	5 ft	(1.52m)
Elevation of top of gate in closed position	7953.00 ft asl	(2424.10 masl)
Type of hoisting	Manually operated –Mechanical stem rod system	
Interlocking device	1 set	
Normal rate of gate opening	0.3 ft/min	91.44 mm/min
Normal rate of gate closing	1.0 ft/min	304.8mm/min

### 2.10.9 Slide Gates at Penstock Inlet

Two (02) Nos. manually operated slide gates shall be provided at inlet of both Penstocks to close the water inflow in case of powerhouse shut down for inspection, repair and refurbishment of the penstock and turbine components as shown on the drawings. The gates are to be operated under un-balanced head condition with the help of individual manually operated stem rod hoists of adequate capacity. The gates and embedded parts shall be designed to withstand an un-balanced Hydro dynamic head of 6.0m or more corresponding to the maximum surge level.

The Contractor will submit his own design calculations for embedded parts, skin plate thickness and number of girders/ members considering the maximum flood level of 7996.61 ft. with a total head of 20 ft.

**Table-2.13: Data of manually operated slide gate:**

i)	Type of Gate	Slide gate with upstream skin plate and upstream seals, regulating type i.e. may be kept at partial opening.
ii)	No. of openings	Two (2 )
iii)	No. of gates	Two (2 )
iv)	No. of embedded parts	2 Sets

iv)	Clear width of each opening	4 ft (1.21m)
v)	Clear height of opening	4 ft (1.21m)
vi)	Sill level	7953.50 ft.asl (2424.25 masl)
vii)	Max. Flood Level	7996.61 ft.asl (2437.39 masl)
vii)	Level at full open position	7957.50 ft.asl (2425.47 masl)
viii)	Design head	20 ft (6.1m)
ix)	Type of side & top seals	Music note Teflon clad rubber.
x)	Type of bottom seal	Rubber, wedge
xi)	Position of skin plate & side seal	Up Stream
(xii)	Lowering/raising speed of hoist	11.8 in/min (30 cm/min)
xiii)	Operation	Lowering / raising under unbalanced head conditions by stem rod hoist.
xiv)	Permissible Stresses	Wet & Accessible, DIN or US Corps manual

### 2.10.10 Draft Tube Stoplogs

Two (02) Nos. stoplogs shall be provided, one on each draft tube to close the draft tube for inspection, repair and maintenance purposes. Stoplogs shall have skin plates on downstream side.

A set of stoplog shall consist of not more than two sections of almost equal height. Each stoplog unit shall be capable of self-closing i.e. by gravity under its own weight. Embedded parts for stoplog shall be provided in the bay. Stoplog units when not in use shall be supported on dogging latches provided on draft tube platform.

The stoplog is a vertical lift, slide type of fabricated steel construction and shall be formed by two vertical end girders between which horizontal girders are spaced according to design loads and the downstream face is covered with a skin plate.

The stoplog in two non-interchangeable of equal size units is provided with two lifting lugs.

Stoplog units shall be provided seals on downstream side. Side seals shall be of rubber music note type and bottom seal of rubber wedge type. The seals shall be fastened to the stoplog unit using stainless steel bolts and nuts.

Stoplog unit shall be provided with two guide shoes on each side. The stoplog units shall be handled by a JIB crane using a lifting beam capable of grappling and un-grappling of stoplog unit under water. The lifting beam shall be attached to the hoist at two points.

The JIB crane Hoist shall be installed on steel structure above stoplog grooves along downstream wall of the powerhouse as shown on the drawings. Electric power will be provided through a trailing cable and reeling drum arrangement. Necessary brakes, overload protection, interlocks etc. shall be provided. All drive and hoist gears will be fully enclosed.

### Data

i)	Type of Stoplog gate	Vertical lift, slide with downstream skin plate and downstream seals, non-regulating type i.e. not to be kept at partial opening.	
ii)	No. of Bay	2	
iii)	No. of stoplog sets required	2	
iv)	Clear width of opening	4 ft	(1.21m)
v)	Clear Height of stoplog	3.35 ft	(1.02m)
vi)	Sill level	7932.59 ft. asl	(2417.88 masl)
vii)	Max. Flood Level	7950.00 ft. asl	(2423.189 masl)
viii)	Design head	20 ft.	(5.82 m)
ix)	Type of side seals	Rubber, music note Type	
x)	Type of bottom seal	Rubber, wedge Type	
xi)	Position of skin plate & seals	Down Stream	
xii)	Permissible Stresses	Dry & Accessible, DIN or US Corps manual	
xiii)	Lowering / raising speed of hoist	0.75 m/min to 1.5 m/min	
xiv)	Traveling speed of hoist	4.0 m / min. to 8.0 m / min.	
xv)	Operation	Lowering / rising under balanced had conditions by JIB Crane Hoist. & Lifting Beam of adequate capacity	

## 2.11 PENSTOCK PIPE & ITS ACCESSORIES

Two (02) Penstocks; one separate for each turbine, sizing 1.5 m (4.9ft) dia. and approximate length of 52 ft have been proposed to be laid mostly on ground however it shall be rested on saddle supports and encased in concrete where necessary.

- ii) Each penstock is designed to carry a discharge of 3 m<sup>3</sup>/s with rated net head of 6.10m.
- iii) The preliminary thickness of the penstocks as proposed varies from 8 mm to 12 mm considering a pressure rise of 25%; however, during the detail design stage the Contractor shall carry out hydraulic transient analysis considering the turbine closing time and then finally carry out the structural analysis of the complete penstock and firm up the thicknesses.
- iii) The total length of the penstock given above may vary subject to adjustment to suit the final dimensions adopted for the detailed layout.

### 2.11.1 Scope of Work

The work comprises of design, procurement of materials, fabrication, shop assembly, testing, stress relieving, shop painting, supply, transportation, loading/unloading, stacking, storage of penstock and all accessories in the yard, erection, hydrostatic testing, field painting, testing and commissioning of the penstock comprising of straight shells/cans air vent pipes, pressure relief valves, bends, expansion joints after each anchor block, anchor bolts, stiffeners, reducers, make up pieces, Manholes, connection piece between penstock branches and flanged connection of main inlet valve etc. & piezometric connection complete in all respects in accordance with these specifications and drawings.

In addition to above, scope of work also includes spares parts required for satisfactory operation and maintenance of penstock and it's accessories for a period of 5 years from the date of commissioning of the project.

Notwithstanding brief description of items, all accessories, apparatus or works not sufficiently mentioned in these specifications but which may otherwise be necessary for ensuring complete supply, erection, testing, commissioning and flow measuring devices/instrumentation of the penstocks covered under these specifications shall be deemed to be the responsibility of the Contractor.

### 2.11.2 Design Criteria

The Penstock and all other steel structures shall be designed not only for a maximum design internal pressure of 8 m inclusive of pressure rise of 25% (to be confirmed by the Contractor through hydraulic transient's analysis) but also for external loads due to earth fill and live loads. The Contractor shall take into account factors like local ambient temperatures variation, earthquake forces, snow load etc.

### 2.11.3 Design Data

The design data for the penstocks and steel lining is broadly appended below:

Normal Water Level (NWL) at Fore-bay	7969.25 ft asl	(2429.05 masl)
<b>Centre of Main Inlet Butterfly Valve</b>	<b>7947.80 ft asl</b>	<b>(2422.51 masl)</b>
<b>Plant Design Discharge</b>	<b>6 m<sup>3</sup>/s</b>	
<b>Unit Design Discharge</b>	<b>3 m<sup>3</sup>/s</b>	
<b>Gross Head</b>	<b>27 ft</b>	<b>(8.23m)</b>
<b>Rated Head</b>	<b>25.3 ft</b>	<b>(7.72m)</b>

#### 2.11.4 General Requirements

- i. Plates of normalized fine grain steel conforming to ASTM A516 Gr.70 Nor. shall be 100% ultrasonically tested and certified at the Manufacturer's shop. The penstock, bends shall be subjected to hydrostatic testing. The welded joints shall be subjected to appropriate NDT. It is intended that all shop fastenings and field fastenings shall be of welded type unless otherwise specified.
- ii. Wherever possible, fabrication at site should be done by automatic welding. Suitable equipment for doing such type of work is a pre-requisite for a bid being considered. The manufacturer must have in his shop, satisfactory facility of plate bending, edge preparation and end milling of members as advised by the Employer/Engineer's supervisory staff.
- iii. Fabrication of steel work shall be at the manufacturer's regular workshop or at a field workshop to be set up by the Contractor in the project area. Shop fabrication of heavy parts and other specials, requiring precision finishing such as bends, and branch pipes or vent pipes shall be done in regular workshops.

#### 2.11.5 Layout

- i. The Contractor shall complete all preliminary works at site well before the arrival of penstock and all other steel structures such as electrical winches, rail tracks, mobile cranes, all poles, all tools and tackles, welding sets etc. as part of this Contract, together with any other work that may be necessary to start erection immediately. The Contractor shall arrange for such number of erection equipment, supervision, labour and other arrangements as are necessary to carry out the work efficiently and in accordance with an approved plan of work.
- ii. The Contractor shall be solely responsible for correctness of laying the penstock and all other steel structures. The checking and approval by the Employer/Engineer's supervisory staff will not absolve the Contractor from the responsibility of erecting the penstock and all other steel structures such as bends, reducers, bifurcations/manifold etc. in true alignment. Establishing and maintaining temporary benchmarks and connecting to the permanent benchmarks by double leveling shall be the responsibility of the Contractor for which no extra claims shall be made.

### **2.11.6 Specifications & Standards**

These specifications are intended for the partial description of quality, workmanship etc. desired for the items covered in the scope of work. The specifications are not however, intended to cover all the minute details and the work shall be executed in accordance with the spirit of the bid specifications. In the absence of specifications for any particular item of work it shall be executed as per the Standards/Codes mentioned hereunder.

1. AISI Steel Pipe Engineering Data-Volume 3&4
2. ASCE Engineering Practice No. 79
3. Steel Pipe-A Guide for Design and Installation-AWWA Manual-11
4. Technical Standards for Penstock and Gates by Nippon Corporation
5. Stress and Strain Handbook by Roark
6. Manual of Steel Construction
7. ASME VIII Unfired pressure Vessel code
8. ASTM Standards
9. Steel Structures Painting Council (SSPC) Specifications for Surface Preparation and Painting

### **2.12 DEFECT LIABILITY PERIOD**

The Contractor shall warrant that the facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the Plant supplied and of the work executed.

The Defect Liability Period shall be three hundred and sixty five (365) days from the date of signing the "handing over/taking over certificates" for all completed facilities individually.

If during the Defect Liability Period and defect should be found in the design, engineering, materials and workmanship of the Plant supplied and of the work executed by the Contractor, the Contractor shall be promptly in consultation and agreement with the Employer/Engineer regarding appropriate remedying of the defects, and at his own cost, shall repair, replace or make good the defects such that the equipment or facilities shall be deemed as the new and the DLP shall be recommenced.



**ANNEXURE 1: Specifications of turbine components to be provided by the Contractor**

<b>S.No</b>	<b>Items</b>	<b>Specifications (Sizes, Types, Make)</b>	<b>Material / Standard</b>
1	Side Plate		
2	Runner diameter		
3	Runner RPM		
4	Turbine specific speed		
5	Runaway Speed		
6	Total weight of the turbine		
7	Weight of the shaft		
8	Side disk		
9	Intermediate disk		
10	Rotor Shaft		
11	Shaft Distribution		
12	Rotor Blade		
13	Allen Key Bolt		
14	Eye Bolt		
15	Bearing (SKF)		
16	Bearing Cover (SKF)		
17	Rotor Key		
18	Hexagonal Screw		
19	Screw		
20	Hand Regulator Spindle		
21	Spindle Nut		
22	Lever for Valve		
23	Hub for Hand wheel		

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24	Hand Wheel		
26	Pulley		
27	Foundation		
28	Penstock Flange            Adaptor		
29	Jigs and Fixture		
30	Tool Kit		
31	Lifting and handling equipment		

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# **EMPLOYER'S REQUIREMENTS**

## **CHAPTER-3**

### **TECHNICAL REQUIREMENTS FOR ELECTRICAL WORKS**

250 KW SBBU Micro Hydropower Project

## EMPLOYER'S REQUIREMENTS

### General Technical Specifications (Electrical)

#### ELECTRICAL EQUIPMENT

**a) Cylindrical Rotor Synchronous Generator**

Supply, installation, testing and commissioning of Two (2 Nos.) cylindrical rotor synchronous generators with allied equipment, as per IEC 61116 or conforming to IS 4722.

**b) LV Switchgear**

Supply, installation, testing and commissioning of 0.4 kV low voltage, metal clad type switchgears with built in control and protection features

**c) Control, Protection and Instrumentation**

Supply, installation, testing and commissioning of control, protection and instrumentation equipment as per technical and operational requirements

**d) Auxiliary Supply**

Supply, installation, testing and commissioning of equipment for auxiliary supply as per technical and operational requirements of Powerhouse and Intake area.

**e) Lighting and Earthing System**

Supply, installation, testing and commissioning of lighting and earthing as per technical and operational requirements.

**f) Electricity Distribution System**

Supply, erection, installation, testing and commissioning of electricity distribution through underground cables and allied change over facilities within the distribution boards for electricity supply to different blocks in the project site.

**1. Standards**

WAPDA/NTDC standards shall be preferred for design, manufacturing and installation of electrical equipment. However, IEC/IEEE standards or any equivalent standard (with prior approval of the Engineer) shall be applicable in case of WAPDA/NTDC standards are not available for some high-tech equipment like synchronous generator, control/protection etc.

**2. Alternator / Generator**

The generator shall be of the horizontal shaft, water wheel driven, three phases, 415V, 50 Hz, including allied equipment, foundation frame & pulley, etc.

The generator and bearings will be able to withstand transient and continuous runaway speed for five minutes without any consequential damages.

### Main Technical Parameters

Sr. No.	Item	Value
1	Nominal Capacity	162 KVA (130 KW)
2	Nominal Speed	500 rpm
3	Rated Voltage	415 V AC
4	Phase/Wire	Three Phase, Four Wire
6	Insulation Class of Stator/Rotor Windings	F
7	Ingress Protection Code	IP 22 / 23
8	Rating Power Factor	0.8 lagging to 0.9 leading as per NEPRA SRO 1005
9	Altitude	As per site (for heights > 1000 m corrections should be made as per Clause 6.3 of IS 12802
10	Efficiency	>90%
11	Winding	Copper

### Construction

The stator frame shall be of cast iron fabricated steel construction. The frame shall be designed to withstand bending stresses and deflections due to its weight and weight of the complete core to be supported by it. The stator core shall be built up of low loss, non-oriented steel sheets and end plates. The stator winding shall be of multi-turn or single turn type shall be insulated with class F insulation level and class B temperature rises. The stator winding shall be star connected with both ends of conductors of each phase brought out of the stator.

The design and construction of rotor shall be in accordance with the best modern practice. Field winding shall consist of fabricated field coils or any other type with adequate provision for cooling purpose.

The generator neutral shall be grounded to limit fault current and the generators shall be designed to safely withstand any electromechanical and / or magnetic stresses resulting from either a three phase or a single-phase fault.

The generator shall be of robust design made of high-quality materials and as far as possible maintenance free, or easy to be repaired locally.

### Automatic Voltage Regulator

An automatic voltage regulator shall be provided with each generator for the automatic control of the generator.

### Exciter

For such small horizontal machines, rotary excitation system with full wave diode rectifiers, automatic/manual channel, etc. directly mounted on generator shaft, conforming to acceptable relevant international standards shall be suitable.

### 3. Low Voltage Switchgear

The low voltage AC distribution system will be designed as 3-phase, four wire system. The low voltage equipment in the plant shall comprise of MCB and MCCB's including all apparatus and requisite accessories, busbars, conductors, clamps and connections, indication lights, CTs, busbars, earthing devices, internal wiring and terminals, base frames and fixing materials etc.

The switchgear will be assembled on demand, and/or according to the Employer/Engineer requirements.

Sr.	Item	Value
1	Type	Floor Mounted
2	Installation	Indoor
3	Rated Current	As per design
4	Rated Short-circuit withstand	As per design
5	Nominal voltage	415 V
6	Bus Bar	Three phases, neutral and ground, pure copper

### 4. Control and Protection System

The general concept of protection systems for major equipment of plant shall be as follows;

For Generators, following protections at minimum shall be provided:

- Overcurrent
- Overspeed
- Over/Undervoltage
- Earth fault
- Phase Imbalance
- Over / under frequency

### 5. Earthing System

The earthing system shall be designed as per relevant IEEE standards and grounding resistance shall be not more than 1 ohm. The principle objective of earthing system is to protect personnel and public from dangerous potentials such as transferred potentials, touch and step potentials and mesh potentials during normal /abnormal operating conditions and maximum ground fault conditions. Design of earthing system is mainly dependent on soil

resistivity and short-circuit level of installed electrical equipment. A complete earthing system consisting of copper conductor mesh, ground rods, joints, interconnection of equipment with earthing mesh shall be provided for this purpose whose details will be decided later based on earth resistivity survey.

For protection against lightning discharges, a suitable lightning protection system comprising of lightning arresters with spikes if needed, lightning rods, copper strip / conductor, earthing rods etc. shall be provided. Details will be decided during detail design.

## 6. Lighting and Small Power

An LED based adequate indoor and outdoor lighting system with illumination levels according to international standards shall be supplied. A battery backed emergency lighting system shall also be installed.

Type of Area	Illumination Level
<b>Outdoor</b>	
Areas with common staff traffic	100 lux
Roads and transformer yard.	100 lux
<b>Indoor</b>	
Offices, machine hall, switch-gear rooms etc.	300 lux
<b>Emergency</b>	
Emergency Indoor lighting	1 Lux